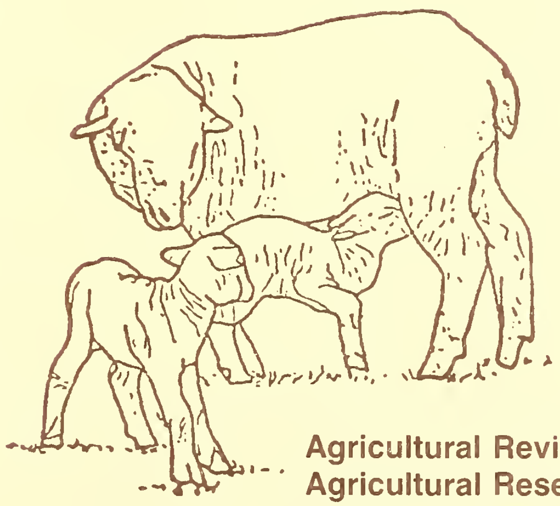
Sheep Research Program

Progress Report No. 1

Roman L. Hruska
U.S. Meat Animal Research Center

In cooperation with
University of Nebraska College of Agriculture
The Agricultural Experiment Station



Agricultural Reviews and Manuals
Agricultural Research Service
U.S. Department of Agriculture

ARM-NC-16

August 1981

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Published by Agricultural Research Service
North Central Region
U.S. Department of Agriculture
2000 W. Pioneer Parkway
Peoria, Ill. 61615

Library of Congress ISSN 0193-3787

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U.S. MEAT ANIMAL RESEARCH CENTER[1]

1. **Overview of Center:** The U.S. Meat Animal Research Center (MARC) was authorized by Congress on June 16, 1964, thereby creating a single facility that provides an unusual opportunity for making major contributions to the solution of problems facing the U.S. livestock industry. Development of the 35,000-acre facility started in the spring of 1966 and is continuing at the present time. Phase I construction, consisting of an office-laboratory building for intensive investigations, was completed in January 1971. These facilities provide a physical plant for 42 scientists and about 200 support personnel. Phase II construction, consisting of the Meats Research Laboratory and Agricultural Engineering Building, was completed in October 1977 and provides a physical plant for 25 scientists and about 60 support personnel. Phase III construction will provide facilities for a comprehensive research program of producing, harvesting, handling, storing, and using forages in livestock production systems. Approximately 35 additional scientists and 65 support personnel will be required for this phase. Currently, one-third of the scientific staffing is completed.

Approximately one-half of the research program is devoted to beef cattle, one-fourth to sheep, and one-fourth to swine. Current research program objectives require breeding-age female populations of approximately 7,500 cattle (20 breeds), 5,000 sheep (9 breeds), and 500 swine (8 breeds) litters per year.

The research program at the Center is organized on a multidiscipline basis and is directed toward providing new technology for the U.S. livestock industry by extending investigations into new areas not now being adequately studied. The research program complements research conducted elsewhere by the U.S. Department of Agriculture and is cooperative with the Nebraska Agricultural Experiment Station and other Land Grant university agricultural experiment stations throughout the country.

On October 10, 1978, the President signed into law a bill renaming the U.S. Meat Animal Research Center the Roman L. Hruska U.S. Meat Animal Research Center. The purpose of the bill was to honor former Nebraska Senator Roman L. Hruska for "his efforts in the establishment of a centralized federal facility for the research, development, and study of meat animal production in the United States."

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[1]Agricultural Research Service, U.S. Department of Agriculture, the University of Nebraska, and other cooperating Land Grant universities.

2. **Overview of Sheep Research Program:** MARC's sheep research program places the highest priority on the development of intensive and semi-intensive sheep production system technology capable of having an immediate impact on the sheep industry. Although the program is largely oriented towards fundamental research, emphasis is placed on the generation of technology that can be practically implemented by small farmers and commercial sheep producers alike within a relatively short time frame. Specific research efforts are not oriented toward wool production problems because of research efforts relating to wool in State Agricultural Experiment Stations and other USDA research centers.

The sheep research program is organized on a multidiscipline basis with the focus on the solution of specific problems that represent the greatest technological constraints to improving production efficiency and product desirability. The program is also designed to complement existing domestic and international research programs in the development of sheep production technology.

The contents in this report represent a cross section of our sheep research program at the present time. Since some of the projects from which results are reported are still in progress, the preliminary nature of some of the results must be recognized. However, it is our opinion that information useful to the industry should be provided at the earliest possible time. Progress reports of this nature will be released periodically to make current results available to the sheep industry. For convenience, the research program is reviewed on a discipline basis in this report with problem areas listed under the disciplinary unit that is taking the lead on research programs in each specific problem area.

Robert R. Oltjen

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BREEDING AND GENETICS

SELECTION CRITERIA FOR MARKET LAMB PRODUCTION

Kreg A. Leymaster[1], Larry W. Olson, and Gordon E. Dickerson

Summary

Genetic and phenotypic parameters for preweaning and postweaning growth and carcass traits were estimated from data on 2,227 Suffolk, Hampshire, Dorset, Rambouillet, Targhee, Corriedale, and Coarse Wool lambs weaned at 8 to 14 weeks of age, 894 ram lambs fed and 584 slaughtered, by 117 sires over 3 years. Growth traits were weights (W) at birth (0), 10, 14, 18, 22, and 26 weeks of age and average daily gains (G) by periods. Carcass traits were weight (CW), leg (LC) and carcass (CC) conformation, quality grade (QG), % kidney fat (KF), and back fat thickness (FT). Additive adjustment for large effects of type of birth-rearing and age of dam was required for W0, W10, GO-10, and G10-14. Paternal half-sib heritabilities (h^2) were 18% for W10, 19% for GO-10, 44% for W22, 46% for G14-22, 48% for G18-22, and 43% for predicted weight of boneless major cuts (BC). Relative usefulness in selection for meat production is indicated by correlation with breeding value for G14-22, W26 and BC; these were highest for W22 (.60, .61, and .63), W26 (.58, .60, and .55) and G14-22 (.68, .66, and .52). Selection for individual growth of early weaned lambs is expected to be nearly as effective for improving carcass value as direct selection for individual carcass value would be, if that were possible.

Introduction

Market lamb production under intensive management and feeding systems is of increasing importance to the sheep industry. A primary breeding objective to improve market lamb production should be to increase the efficiency of lean growth through selection programs. Rate and composition of lamb growth are major determinants of lean growth efficiency. The usefulness of live animal measures of body composition as a selection tool depends upon the way in which both meat quantity per day of age and meat quality would be affected by selection based upon live weight alone.

The purpose of this study was to estimate the genetic relationships among various growth and carcass composition characteristics and to compare alternative selection criteria. Alternative selection criteria were evaluated in terms of expected direct and indirect effects on lamb meat production at a constant market age.

Materials and Methods

Genetic and phenotypic parameters for preweaning and postweaning growth and carcass traits were estimated from data on Suffolk, Hampshire, Dorset, Rambouillet, Targhee, Corriedale, and Coarse Wool lambs produced at MARC during 1969, 1970, and 1971. The preweaning, postweaning, and carcass data sets included information on 2,227 ram and ewe lambs, 894 ram lambs, and 584 ram lambs, respectively.

A pelleted creep ration of 50% dehydrated alfalfa meal and 50% ground shelled corn was available to lambs soon after birth. Lambs were weaned at 8 to 14 weeks of age and given a 2-week adaptation period prior to initiation of the postweaning test. All ram lambs were fed to at least 22 weeks of age and randomly assigned to slaughter at 22, 26, 30, or 33 weeks of age. Growth traits recorded were (W) at 0, 10, 14, 18, 22, and 26 weeks of age and (G) by periods. Carcass traits, adjusted to a constant age, were (CW), (LC) and (CC), (QG), (KF) and (FT). In addition, (BC) was predicted by utilizing FT, KF, and LC in a regression equation.

Genetic and phenotypic parameters were estimated by paternal half-sib mixed model analyses of variances and covariances. The fixed effects of type of birth-rearing and age of dam (both linear and quadratic) were included in the statistical model of each data set. Age at slaughter was also included as a continuous variable to adjust carcass traits to a constant age basis. Alternative selection criteria were compared by estimating the relative expected correlated (indirect) responses to selection, measured in genetic standard deviation units per unit of selection intensity.

Results and Discussion

The analyses indicated that type of birth-rearing and age of dam effects significantly influenced lamb performance (Table 1). Birth-rearing effects were large and highly significant on preweaning gain (G0-10 and G10-14), smaller on G14-18, and reversed on G18-22. Accordingly, postweaning weights and carcass traits, except KF, were also significantly affected by type of birth-rearing effects, due to their part-whole relationship with preweaning gain. In general, single born and reared lambs gained faster and were heavier at a given age than twin born-single reared or twin born-twin reared lambs.

Significant age of dam effects were noted for G0-10 and G18-22 with the latter effect indicative of compensatory gains by lambs limited by preweaning maternal effects. Age of dam effects on weights

Table 1.—Birth-rearing effects and linear and quadratic age of dam effects on growth traits of ram lambs

	Types of birth rearing				Age of dam	
Trait[1]	Born single, reared single	Born twin, reared single	Born twin, reared twin	Born triplet or quadruplet	Linear	Quadratic
G0-10[2]	0.52	0.47	0.41	0.42	0.045	−0.004
G10-14	.62	.55	.54	.52	.024	−.003
G14-18	.77	.73	.72	.64	.021	−.002
G18-22	.71	.69	.77	.79	−.057	.006
G14-22	.74	.71	.75	.72	−.018	.002
G10-18	.69	.64	.63	.58	.022	−.002
G10-22	.70	.65	.68	.65	−.003	.001
W0	11.2	9.2	9.2	7.8	.75	−.06
W10	47.8	42.6	38.0	37.2	3.90	−.37
W14	65.3	58.0	53.1	51.9	4.59	−.44
W18	86.8	78.4	73.3	70.0	5.18	−.51
W22	106.8	97.6	94.8	92.1	3.57	−.33
W26	125.3	115.2	113.1	109.5	5.27	−.49

[1]Daily gains (G) and weights (W) are in pounds.
[2]0, 10, 14, etc., represent weeks of age. For example, G14-18 is daily gain from 14 to 18 weeks of age, and W 22 is weight at 22 weeks of age.

[1]Kreg A. Leymaster is a research geneticist at MARC.

were large and curvilinear for W0, W10, W14, W18, and W22. At all ages, the heaviest lambs were from 3- to 7-year-old ewes and the lightest lambs were from 1-, 2-, and 9-year-old ewes. Age of dam effects on carcass traits were significant only for KF.

The type of birth-rearing and age of dam effects presented above agree in general with numerous reported studies utilizing early weaned lambs. The practical implication is that selection schemes for postweaning weight would be more effective if correction factors for age of dam and type of birth-rearing were utilized. However, correction factors for postweaning daily gain, G14-22, are less of a necessity due to the compensating effects discussed above.

Table 2.—Heritabilities of various growth traits and expected genetic changes of several selection objectives[1]

Trait[2]	Percent heritability	Genetic change to[3] G14-22	W26	BC	QG
W0	35	–0.06	–0.06	–0.16	–0.48
W10	18	.40	.40	.45	–.07
W14	21	.25	.29	.42	.21
W18	34	.37	.46	.57	.30
W22	44	.60	.61	.63	.38
W26	36	.58	.60	.55	.24
G0-10	19	.35	.35	.40	–.01
G10-14	30	–.01	.06	.23	.49
G14-18	31	.36	.51	.44	.26
G18-22	48	.60	.45	.35	.31
G14-22	46	.68	.66	.52	.38
G10-18	26	.22	.36	.42	.52
G10-22	38	.52	.55	.52	.59

[1]Table constructed from Olson *et al* (1976 a,b)
[2]Traits defined in table 1
[3]BC represents weight of boneless major cuts and QG represents quality grade.

Heritability of a trait is the single most important parameter in determining the effectiveness of a selection scheme. It is indicative of the relative importance of genetics in affecting the phenotype or performance of individuals. Estimates of heritabilities of various measures of growth are presented in Table 2. G0-10, G10-14, G14-18, and G18-22 represent separate periods of growth, whereas other gains are combinations of these periods. Estimated heritabilities of period gains increased as preweaning influences diminished (i.e., 30% for G10-14 to 48% for G18-22). This trend stresses the importance of measuring postweaning gain after 2- to 4-week adjustment period in order to improve accuracy of selection.

Heritabilities of postweaning weights increased from 18% for W10 to 44% for W22, again indicating the declining importance of maternal effects as postweaning growth advances. The high heritability of W22 and its high correlations with all measures of postnatal growth indicate that feedlot growth after early weaning should be an effective criterion for improving genetic growth potential of lambs.

One method of evaluating alternative selection criteria is to compare the expected genetic change in the selection objective. If the selection objective is a measure of growth, then G14-22 or W26 would be suitable traits. The expected genetic changes of G14-22 and W26 are presented in Table 2. With regards to G14-22, direct selection for G14-22 would be most effective (.68) followed by W22 (.60) and G18-22 (.60). Greatest improvement in W26 would result from indirect selection for G14-22 (.66) or W22 (.61) or direct selection for W26 (.60).

Another selection objective to be considered is BC at a constant age, which combines composition of gain with growth rate. As indicated in Table 2, the most effective live animal traits would be W22 (.63), W18 (.57), W26 (.55), G14-22 (.52), and G10-22 (.52). Direct selection for BC, if that were possible, would result in an expected change of .66, only 5 to 27% better than indirect selection. Improvement in QG would also be anticipated as indicated in Table 1.

These results suggest that the primary opportunity to improve meat production per lamb lies in selection for growth rate. The most desirable selection criteria are W22, W26, and G14-22, which would also have little effect on birth weight. An advantage might be given to G14-22 since it is affected very little by type of birth-rearing and age of dam effects and thus could be used without adjustment.

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BREEDING AND GENETICS

COMPARISON OF THE COLUMBIA AND SUFFOLK BREEDS AS SIRES OF MARKET LAMBS

Kreg A. Leymaster[1] and Gerald M. Smith

Summary

Eighteen Columbia and 10 Suffolk rams were single-sire mated to 473 ewes to evaluate sire breed effects on ewe productivity and lamb growth and carcass composition. Breed of sire effects on ewe prolificacy and litter weights at both birth and weaning (49 days of age) were insignificant. Columbia-sired lambs were lighter at birth (7.0 *vs* 7.4 lb), had lower preweaning daily gains (.49 *vs* .52 lb/day), and were consequently lighter at weaning (31.8 *vs* 33.5 lb) than Suffolk-sired lambs. Sire breed effects on postweaning daily gain and 154-day weight favored the Suffolk breed although the advantage was not significant. Whereas Suffolk-sired lambs excelled in carcass and leg conformation scores, progeny of Columbia rams had less fat and a higher percentage of trimmed retail cuts. Retail cuts per day of age, the product of growth rate and carcass composition, averaged .228 lb for offspring of Columbia rams compared to .235 lb for Suffolk-sired lambs. This slight advantage of the Suffolk breed was not statistically significant. Columbia-sired lambs grew slower but produced leaner carcasses than Suffolk-sired lambs. In terms of meat production, it would appear that Columbia rams were competitive with Suffolk rams as sires of market lambs.

Introduction

The utility of a terminal sire breed is measured indirectly through productivity of the ewe flock and production efficiency of progeny. Many studies have been conducted throughout the world evaluating numerous sheep breeds for their potential role as a specialized sire breed. The Suffolk has consistently excelled in various measures of growth rate when evaluated either as a purebred or a crossbred lamb (Dickerson *et al.*, 1972; Nitter, 1975; More O'Ferral and Timon, 1977). This advantage has generally increased when carcass composition is included as a component of lean growth production efficiency. A drawback is the relatively low survivability of Suffolk-sired crossbred lambs reported from several studies (Sidwell and Miller, 1971; Fahmy *et al.*, 1972; Carter; and Kirton, 1975; Smith, 1977). The sheep industry would benefit by availability of a second sire breed of equal lean growth potential to the Suffolk. This would offer the opportunity to exploit heterosis for male reproduction, primarily through increased libido and longevity.

The purpose of this experiment was to evaluate the Columbia breed, relative to the Suffolk, as a terminal sire breed. The extreme mature size of the Columbia breed warranted its evaluation as a potential terminal sire breed. The two breeds were compared for effects on ewe productivity and lamb survivability, growth, and carcass composition.

Materials and Methods

In the winter of 1977, 473 ewes were single-sire mated to either Columbia or Suffolk rams for a 35-day breeding season. Ewes were either 50%, 75%, 87%, or 100% Finnsheep breeding and ranged from 1 to 7 years of age. Suffolk rams were chosen based on individual performance and/or progeny test for growth rate; an additional 2 yearling rams were purchased from purebred breeders and included in the experiment. The Columbia breed was sampled during May of 1977 by purchasing 18 yearling rams out of 11 flocks. Rams were chosen based on extreme size and muscle mass, as growth records were not available.

Lambs were born during May and June of 1978, and pelleted creep feed was provided shortly after birth. Weaning occurred at approximately 7 weeks of age, and lambs were moved to a slotted floor facility for a 4-week adaptation period prior to initiation of individual performance testing. Lambs were fed *ad libitum* and live weights recorded at 28-day intervals until slaughter at either 6 or 7 months of age.

Data were analyzed by mixed model procedures with sires considered as random effects nested within breed of sire. Breed of sire effects were therefore tested utilizing the sires within breed of sire mean square. Various fixed effects such as breed type of dam, age of dam, lambing date, sex, and type of birth-rearing, as well as possible two-way interactions were fitted as appropriate for each trait and subsequently deleted from the model in a step-down procedure. As the primary purpose of this experiment was to compare the Columbia and Suffolk breeds as terminal sire breeds, the remaining fixed effects will not be discussed. The performance of the Columbia breed will be presented relative to the Suffolk, as the Suffolk was utilized as the industry standard.

Results and Discussion

Ewes exposed to Columbia rams resulted in 73.5% conception compared to 80.5% for ewes exposed to Suffolk rams. Number born, survival to weaning, and number weaned were essentially equal for the two sire breeds. This would suggest that the Columbia and Suffolk breeds have similar effects on various measures of ewe prolificacy. Differences in net production efficiency, if they do exist, must therefore result from differential breed of sire effects on growth and/or carcass merit.

Ewes bred to Suffolk rams gave birth to litters with average weight of 16.0 lb and weaned litters at 49 days of age with an average weight of 39.0 lb. Respective figures for Columbia-sired litters were 15.1 lb and 35.7 lb; again, these differences were not statistically significant.

Columbia-sired lambs were lighter at birth (7.0 *vs* 7.4 lb), had lower preweaning daily gains (.49 *vs* .52 lb/day), and were consequently lighter at weaning (31.8 *vs* 33.5 lb) than Suffolk-sired lambs. The advantage of Suffolk-sired lambs was statistically significant for each trait.

Table 1.—Breed of sire effects on ewe productivity

Trait		Columbia	Suffolk	Ratio,[1] percent
Conception[2]	percent	73.5	80.5	91.3
Number born		2.12	2.16	98.1
Birth weight of lambs	lbs	15.1	16.0	94.4
Survival[3]	percent	63.6	66.3	95.9
Number weaned[4]		1.16	1.14	101.8
Weaning weight[5]		35.7	39.0	91.5

[1]Columbia mean as percentage of Suffolk mean.
[2]Percent of ewes lambing per ewe exposed.
[3]Survival to weaning of lambs left on the ewe.
[4]Number weaned per ewe lambing. Excludes lambs artificially reared.
[5]Per ewe lambing

[1]Kreg A. Leymaster is a research geneticist at MARC.

Table 2.—Breed of sire effects on lamb growth

Trait		Columbia	Suffolk	Ratio,[1] percent
Birth weight	lbs	7.0	7.4	94.8
Daily gain-preweaning	lbs day	.49	.52	94.2
Weaning weight	lbs	31.8	33.5	94.9
Daily gain-period 1	lbs day	.45	.47	95.2
Daily gain-period 2	lbs day	.71	.72	98.8
Daily gain-period 3	lbs day	.63	.64	98.7
Total daily gain	lbs day	.60	.63	95.9
154-day weight	lbs	96.5	98.7	97.8

[1]Columbia mean as percentage of Suffolk mean

Postweaning daily gains were calculated for three consecutive 28-day intervals (periods 1, 2, and 3) and total daily gain was also evaluated. Although the Suffolk-sired lambs outgained the Columbia-sired lambs for each period, this difference was not significant. Breed of sire differences in total daily gain, however, approached significance and favored Suffolk-sired lambs.

Weight at 154 days of age represents the sum of prenatal, preweaning, and postweaning growth and as such serves as a measure of cumulative growth potential. The difference in 154-day weights of Columbia- and Suffolk-sired lambs was small, 2.2 lb, and not significant. Although Suffolk-sired lambs grew at a faster rate at each phase of growth to 154 days of age than Columbia-sired lambs, the advantages were relatively minor.

Carcass quality grades did not differ between Columbia- and Suffolk-sired lambs. Lambs out of Suffolk rams had higher carcass and leg conformation scores than lambs by Columbia rams, reflecting differences in shape and thickness of muscling. Columbia-sired lambs were less mature than Suffolk-sired lambs and had thinner body wall thickness (a measure of fat thickness) and a lower percentage of kidney fat. These latter two traits combined with leg conformation score are useful in predicting percent trimmed retail cuts. A slight advantage was noticed for lambs sired by Columbia rams.

A useful measure of production output is retail cuts per day of age as it represents the product of carcass weight per day of age and percent trimmed retail cuts. It thus combines growth rate with carcass composition. The advantage of Columbia-sired lambs in composition was slightly offset by the greater carcass weight per day of age of Suffolk-sired lambs. Thus, Suffolk sires produced .235 lb. of retail cuts per day of age compared to .228 for Columbia sires. This difference was insignificant.

Implications. Progeny of Suffolk rams grew at faster rates through 154 days of age than Columbia progeny. This result is consistent with limited data (Vesley and Peters, 1972; Rastogi *et al.*, 1975; Hohenboken, 1977) comparing the Columbia and Suffolk breed. However, the Columbia breed would appear to be later maturing and had lower measures of carcass fatness. This is advantageous with regards to lean tissue production.

The most pertinent trait available to compare the two populations as terminal sire breeds would be retail cuts per day of age. As stated above, the Suffolk rams were slightly superior to the sample of Columbia rams, although the difference was not statistically significant. Thus, the Columbia breed appears competitive as an alternative to Suffolk rams for the production of market lambs or as a candidate to be included with Suffolks in a composite population based on a crossbred foundation.

Table 3.—Breed of sire effects on carcass merit

Trait		Columbia	Suffolk	Ratio,[1] percent
Carcass quality grade[2]		10.5	10.5	100.6
Carcass conformation score[2]		10.5	10.7	98.9
Leg conformation score[2]		10.4	11.0	94.2
Maturity score[3]		1.9	2.1	90.6
Body wall thickness	inch	.67	.73	92.3
Kidney fat	percent	4.2	4.7	90.2
Trimmed retail cuts[4]	percent	74.7	73.7	101.4
Carcass weight per day of age	lbs/day	.31	.32	96.1
Retail cuts per day of age	lbs/day	.228	.235	97.3

[1]Columbia mean as percentage of Suffolk mean
[2]Scale 0 to 15. 8 = average good. 11 = average choice: 14 = average prime
[3]Scale 1 to 5. 1 = least mature. 5 most mature.
[4]Predicted by using body wall thickness, percent kidney fat, and leg conformation score in regression equation

Columbia germ plasm will be used in a composite population at MARC. A population composed of 1/2 Columbia, 1/4 Suffolk and 1/4 Hampshire germ plasm will be formed by crossing tested Columbia rams on Suffolk-Hampshire crossbred ewes. It is hypothesized that the composite based on a crossbred foundation will provide additional genetic variation to be exploited through selection programs. Also, selection intensity can be improved by greater numbers of offspring to the extent that favorable effects of heterosis on reproduction and survival of lambs are maintained in composite populations. Techniques to improve lean growth efficiency are currently being researched to develop effective selection criteria. As this technology becomes available, the crossbred population will provide animals on which to study the direct and indirect responses to selection for lean growth efficiency. Understanding of these basic biological processes are instrumental to further increasing production efficiency of the sheep industry.

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CROSSING PERFORMANCE OF FINNSHEEP AND DOMESTIC BREEDS

Gordon E. Dickerson[1], Hudson A. Glimp, John D. Crouse, and Danny B. Laster

Summary

Use of 1/2 Finnsheep crosses with such breeds as Dorset, Suffolk, Targhee, or Rambouillet as commercial ewes mated with meat breed sires reduced ewe costs per pound of market lamb by 20 to 25% compared with use of 1/2 Rambouillet x domestic U.S. breed crossbred ewes. The 1/2 Finnsheep crossbred ewe lambs began lambing at 1 year and produced at least 50 more live lambs/100 ewes per year. More of the lambs from 1/2 Finnsheep ewes were twins or triplets and averaged 5 to 6 lb lighter at 10 weeks, but livability, postweaning gain, and carcass yield and grade at the same slaughter weight closely approached that for lambs from 1/2 Rambouillet ewes. The 1/2 Rambouillet crossbred ewes were superior to purebred ewes of the same breeds in fertility and in livability of crossbred lambs.

Breed of sire can affect livability as well as growth rate and carcass desirability of market lambs. Suffolk-sired lambs were superior in growth rate but more of the Oxford-sired lambs lived, making Oxford sires definitely superior in weight marketed/lamb born when mortality was 1/3 or more to weaning at 10 weeks. Hampshire sires were intermediate in both growth and livability of lambs.

Introduction

In the spring of 1970 and 1971, crossbreeding evaluation of the prolific Finnsheep (Donald *et al.*, 1968), the three meat breeds (Suffolk, Hampshire, and Polled Dorset), and three whitefaced breeds (Rambouillet, Targhee, and Corriedale) began at the Center. Ewes of the six U.S. breeds were used to produce Finn-cross (F_x), Rambouillet-cross (R_x), and purebred lambs (P). From 1971 through 1974, all lambs were evaluated for livability and growth, ram lambs for carcass traits (Tables 1 and 2), and female lambs for ewe performance in crossbred lamb production (Tables 3 through 6). Suffolk, Hampshire and Oxford rams sired the market lambs.

Results

Crossbred Lamb Performance. No real differences in livability of Finn-cross lambs were evident among the six U.S. breeds of dam. Differences among the six breeds of dam for growth and carcass traits of crossbred lambs were distinct and very similar to those for purebred lambs, but the differences were smaller because all lambs were by the same breeds of sires (Table 1).

Interest in Finnsheep arises from its superior prolificacy, but there has been concern about its lamb viability, growth, and carcass acceptability. It was encouraging to find that losses of Finn-cross (F_x) lambs to weaning at 10 weeks were only about one-half (19 *vs* 39 or 37%) of those for Rambouillet-cross (R_x) or purebred (P) lambs from ewes of the same six breeds (Table 2). F_x lambs were smaller at birth but not at weaning or at 22 weeks of age. F_x ram lambs were higher than R_x in dressing %, but also in kidney fat, and thus were slightly below R_x in estimated % boneless cut and weight per lamb. Carcass quality and conformation were slightly poorer for both F_x and R_x than for purebred lambs.

Table 1.—Crossbred lamb performance by breed of dam

Trait		Total numbers	Breed of dam: Suffolk	Hampshire	Dorset	Rambouillet	Targhee	Corriedale	Significance[1]
Alive at 10 weeks	percent	[2]1,933	83.0	87.0	79.0	77.0	79.0	75.0	>0.50
Weight at 10 weeks	lbs	[2]1,543	**48**	45	38	41	42	39	<.001
Ram weight at 22 weeks	lbs	[2]700	**111**	102	91	94	96	90	<.01
Ram carcass weight	lbs	[3]783	**66**	62	56	58	61	57	<.001
Dressing	percent		**51.2**	**51.3**	**51.5**	48.5	49.1	48.6	<.001
Grade:[4]									
Quality			**11.4**	**12.3**	**12.2**	10.6	10.9	10.9	<.001
Carcass conformation			**12.2**	**12.8**	**12.7**	11.0	11.2	11.3	<.001
Leg conformation			**12.4**	**12.9**	**12.8**	11.0	11.2	11.3	<.001
Kidney fat	percent		**3.5**	**3.5**	**3.5**	**3.4**	3.8	3.9	<.001
Backfat	inch		.14	.15	**.11**	.13	.16	.17	<.001
Estimated boneless cuts[5]	percent		**45.5**	**45.3**	**45.8**	**45.6**	44.9	44.7	<.001
	lbs		**30.1**	28.0	25.4	26.5	27.1	25.6	<.001

[1]Means set in boldface are extremes for statistically significant breed differences.
[2]Finncross lambs born in spring of 1970, 1971, and 1972 at MARC (Dickerson *et al.*, 1975).
[3]Finncross, Rambouillet cross, and purebred lambs born in spring of 1970 and 1971 at MARC and slaughtered at mean age of 25 weeks (Dickerson, 1974).
[4]Grades from 7 = low good, to 15 = high prime.
[5]Estimated percent boneless major cuts = 47.8 − 11.8 (backfat in) − .44 (pct kidney fat) + .092 (leg conformation) (USDA, 1969).

Table 2.—Lamb performance of Finn (F_x) and Rambouillet (R_x) crosses and purebreds (P) from 7 breeds of dam[1]

Trait		Total numbers	Type of ewe: F_x	R_x	P	Significance[1]
Alive at 10 weeks	percent	3,639	**81.0**	61.0	63.0	<0.001
Weight at birth	lbs	2,725	**8.3**	9.0	9.2	<.001
Weight at 10 weeks	lbs	2,725	41	42	41	>.50
Ram weight at 22 weeks	lbs	1,245	98	99	97	>.10
Ram carcass weight	lbs	928	60	60	61	>.50
Dressing	percent		**51.4**	48.6	50.1	<.001
Grade:[2]						
Quality			11.2	11.1	**11.4**	<.01
Carcass conformation			11.4	11.6	**12.0**	<.01
Leg conformation			11.4	11.7	**12.1**	<.001
Kidney fat	percent		4.8	**3.3**	**3.3**	<.001
Backfat	inch		**.13**	**.13**	.16	<.01
Estimated boneless cuts[3]	percent		45.0	**45.6**	45.2	<.001
	lbs		26.8	27.3	27.4	~.50

[1]Lambs born in spring of 1970 and 1971 at MARC (Dickerson *et al.*, 1975; Dickerson, 1974). Lambs from Coarse Wool breed of dam were included in addition to 6 breeds listed in Table 3. Means set in boldface are extremes for significant breed differences.
[2]Grades from 7 = low good; to 15 = high prime.
[3]Estimated percent boneless major cuts = 47.8 − 11.8 (backfat in) − .44 (pct kidney fat) + .092 (leg conformation) (USDA, 1969).

[1]Gordon E. Dickerson is a USDA research geneticist stationed at the University of Nebraska, Lincoln.

Table 3.—Ewe performance of Finn (F_x) and Rambouillet (R_x) crosses and purebreds (P) from 7 breeds of dam

Trait		Total numbers	Type of ewe F_x	R_x	P	Significance[1]
Weight at 230 days	lbs	[2]644	**87**	90	88	<0.01
Weight at 1st estrus	lbs		**88**	97	99	<.001
Age 1st estrus	days		**219**	238	245	<.001
1st estrus by Nov. 10	percent		**72**	38	34	<.001
Lambs/100 ewes exposed:[3]						
All ages[4]		2,663	**88**	83	76	<.001
At 1 year		822	**85**	66	58	<.001
At 2 years		798	**91**	**91**	86	<.01
At 3 years		774	**88**	**92**	83	<.01
At 4 years		269	**93**	82	79	<.01
Surviving to 3 or 4 years	percent		87	88	--	
Lambs born/100 ewes lambing:[3]						
All ages[4]		2,032	**190**	139	137	<.001
At 1 year		505	**155**	106	108	
At 2 years		633	**194**	138	132	
At 3 years		669	**203**	168	152	
At 4 years		225	**225**	151	173	
Lambs weaned/100 ewes lambing:[3]						
All ages[4]		2,032	**118**	94	84	<.001
At 1 year		505	**73**	58	49	
At 2 years		633	**113**	94	76	
At 3 years		669	**142**	120	103	
At 4 years		225	**170**	117	134	

[1]Means set in boldface are extremes for statistically significant breed differences.
[2]Ewe lambs born in spring 1971 at MARC (Dickerson and Laster, 1975).
[3]Ewes born at MARC in spring 1970 and 1971, lambing in spring 1971, 1972, 1973, and 1974 and weaning at 10 weeks, including 1/2 Coarse Wool ewes (Dickerson, 1974). Litter size = lambs/100 ewes lambing.
[4]Weighting equally each ewe-age and lambing year.

Crossbred Ewe Performance. Finn-cross ewe lambs (Table 3) were only slightly smaller than R_x at 230 days of age but nearly twice as many reached first estrus by November 10 (72 *vs* 38%). About one-third more F_x than R_x lambed at 1 year of age (85 *vs* 66%) and seven-eighths of both survived to 3 or 4 years of age. The initial F_x advantage over R_x in fertility (85 *vs* 66% ewes lambed/exposed at 1 year) vanished after yearling age, but lambs born/ewe averaged much higher for F_x than R_x ewes at 1, 2, 3 and 4 years of age (190 *vs* 139%). Lamb mortality reduced the corresponding F_x advantage in lambs born/ewe at 10-week weaning (118 *vs* 94%) at all ages. R_x equaled purebred ewes in lambs born/ewe at all ages (139 *vs* 137%) but weaned more lambs (94 *vs* 84%).

Breed of dam differences in crossbred ewe performance (Table 4) were real for sexual maturity, fertility, and number of lambs born. More Suffolk and Hampshire than other crosses exhibited estrus as ewe lambs (about 55 *vs* 38%), and Hampshire crosses were youngest at first estrus. Suffolk and Dorset crosses excelled others at all ages in fertility (83 *vs* 78+%) and in lambs born/ewe (166 and 158 *vs* 143 to 150%). Although Suffolk- and Hampshire-cross ewes were poorest in numbers weaned by 1-year-old ewes (39 *vs* 61 to 66%), Suffolk were like Dorset, Targhee, and Rambouillet crosses in lambs weaned by 2-, 3-, and 4-year-old ewes. Hampshire and Corriedale crosses were consistently poor in lambs born and weaned. These results agree reasonably well with rankings based on the 4 years of purebred comparison of these breeds.

Market Lambs from Finn-cross Ewes. The Finn-cross (F_x), Rambouillet-cross (R_x), and purebred (P) ewes born in 1970 and 1971 were mated with Suffolk, Hampshire, and Oxford rams to produce over 3,000 spring market lambs in 1971 through 1974.

Market lambs from F_x ewes (Table 5) survived nearly as well as those from R_x ewes (61 *vs* 65%), even though more F_x lambs were twins or triplets (190 *vs* 139% lambs/ewe, Table 3). Lambs from F_x ewes were smaller at birth (−2.4 lb), 10 weeks (−6 lb), and 22 weeks (−7 lb) of age but gained just as much from 10 to 22 weeks (46 *vs* 47 lb) or to 31 weeks (72 *vs* 73 lb). Lambs from F_x ewes at 31 weeks of age dressed .7% more than those from R_x but had .6% more kidney fat, the same yield grade and estimated % yield of boneless cuts and 1.1 lb less boneless cut weight per lamb. Corresponding differences in trimmed cuts were −.4% and −2.1 lb.

Combining the differences in fertility, lambs born, lamb survival, growth, and carcass composition (Table 6), the net advantage of F_x over R_x ewes in boneless

Table 4.—Crossbred ewe performance by breed of dam

Trait		Total numbers	Dam of ewe Suffolk	Hampshire	Dorset	Rambouillet	Targhee	Corriedale	Significance[1]
Weight at 230 days	lbs	[2]552	**101**	86	79	88	90	85	<.01
Weight at 1st estrus	lbs		**111**	92	85	92	91	96	<.01
Age at 1st estrus	days		234	**225**	230	235	231	240	<.05
1st estrus by Nov. 10	percent		**57**	**53**	48	44	33	27	<.02
Ewes lambed/100 ewes exposed:[3]									
All ages[4]		2,663	**83**	78	**84**	78	79	79	<.001
1 year		822	**72**	66	**75**	58	60	61	<.001
2 years		798	90	89	88	90	86	85	
3 years		774	86	80	84	89	90	87	
4 years		269	85	77	92	70	81	87	
Lambs born/100 ewes lambing:[3]									
All ages[4]		2,032	**166**	144	158	150	150	143	<.001
1 year		505	**135**	120	122	106	120	113	
2 years		633	**155**	141	**156**	**157**	**156**	139	
3 years		669	**189**	160	175	169	167	166	
4 years		225	**205**	166	**199**	**187**	167	162	
Lambs weaned/100 ewes lambing:[3]									
All ages[4]		2,032	**97**	78	**104**	**101**	**103**	87	<.01
1 year		505	39	39	**61**	**66**	**64**	**61**	<.05
2 years		633	**95**	82	**91**	**89**	**105**	83	
3 years		669	**132**	101	**127**	**123**	**126**	101	
4 years		225	**150**	99	**167**	**154**	129	117	

[1]Means set in boldface are extremes for statistically significant breed differences.
[2]For lambs born in spring 1971 at MARC (Dickerson and Laster, 1975).
[3]Ewes born in 1970 and 1971 and lambing in spring 1971, 1972, 1973, and 1974 at MARC (Dickerson, 1974).
[4]Weighting equally each ewe-age and lambing year.

Table 5.—Performance of market lambs from Finn (F_x) and Rambouillet (R_x) cross and purebred (P) ewes[1]

Trait		Lamb numbers	Type of ewe F_x	R_x	P	Significance[2]
Alive:						
At birth	percent	3,184	96.0	97.0	95.0	>0.10
To 4 weeks			74	75	73	>.50
To 10 weeks			61	**65**	59	~.10
Weight:						
At birth	lbs	[1]1,997	**7.2**	**9.6**	**9.2**	<.001
At 10 weeks		1,997	**32.9**	38.6	36.1	<.001
At 22 weeks		1,855	**79**	86	83	<.001
At 31 weeks (slaughter)		1,868	**105.2**	111.5	109.3	<.001
Daily gain 10 to 31 weeks	lbs	1,855	.51	**.54**	**.53**	<.001
Carcass:						
Weight	lbs.	1,868	**53.5**	56.0	54.7	<.001
Dressing	percent		**50.6**	49.9	49.8	<.01
Grade:[3]						
Quality			11.7	**12.0**	11.8	<.05
Leg conformation			**11.9**	12.3	12.2	<.001
Kidney fat	percent		**4.6**	4.0	4.0	<.01
Backfat	inch		**.28**	.29	.30	<.05
Yield grade[3]			4.0	4.0	4.1	>.50
Estimated boneless cuts[3]	percent		43.3	43.3	43.2	>.50
	lbs		**23.0**	24.1	23.5	<.001
Estimated trimmed cuts[4]	percent		73.4	73.8	73.9	<.10
	lbs		**38.8**	40.9	40.0	>.001

[1]Crossbred ewe and wether lambs from 1970 and 1971 ewes lambing in spring 1971 through 1974 by Suffolk, Hampshire, and Oxford sires (Dickerson, 1974). Each lambing year was given equal weight with no adjustment for type of birth and rearing. Birth weights are for lambs surviving to weaning.

[2]Means set in boldface are extremes for significant breed differences.

[3]Grades and boneless cuts as in Table 1. Yield grade = 1.66 + 6.66 (backfat, in) − .05 (leg conformation) + .25 (pct kidney fat) (USDA, 1969).

[4]Estimated percent trimmed retail cuts (leg, loin, rack, shoulder) = 83.72 − 13.9 (body wall, in) − 1.31 (pct kidney fat) + .56 (leg conformation) (Tuma *et al.*, 1968).

lamb production per ewe exposed averaged about 27% (54% at 1 year of age, 22% at 2 years, 8% at 3 years, and 58% at 4 years) on the basis of numbers weaned. With more intensive management, the F_x advantage would be greater (36%) as indicated for numbers alive at birth in Table 6. More adequate nutrition of prolific F_x ewes may permit a still larger advantage over R_x ewes. The R_x ewes have a large relative advantage over purebred ewes, whether based on lambs alive at birth (100 *vs* 88%) or at 10-week weaning (100 *vs* 83%). If differences in fleece value, size of ewe, and ewe costs associated with lambs born per ewe were included, the F_x advantage over R_x ewes would be somewhat less but still a very impressive increase of 20 or 25% in returns per unit of ewe costs.

Market Lambs by Breed of Ewes' Dam. Which domestic breeds produced the most efficient crossbred ewes? As shown in Table 7, lamb viability was superior for 1/2 Dorset, Rambouillet, Targhee, or Corriedale ewes. Lambs from 1/2 Suffolk or 1/2 Dorset ewes were nearly 1 lb lighter at birth, but differences in weight were slight at 22 and 31 weeks of age. Dressing %, leg conformation, and kidney fat were superior for lambs from ewes of one-half meat breed origin. Yield grade and boneless trimmed cut yields were best for lambs from 1/2 Suffolk and Rambouillet ewes.

Effects of ewe age on lamb performance did not differ with breed of ewes' dam; thus, breed of dam effects on boneless lamb production of ewes can be averaged over ages of ewe (Table 8).

In terms of *expected* boneless lamb per ewe exposed based on actual lambs alive at 10 weeks, the most promising domestic breeds for producing Finn-cross ewes (Table 8) were Dorset (110%), Suffolk (106), Targhee (102), and Rambouillet (100). With better husbandry control of lamb losses, the ranking would shift toward Suffolk (114%), Dorset (106), Rambouillet (100), and Targhee (98). Accelerated lambing would be expected to favor crossbred Finn-Dorset or Finn-Rambouillet ewes (Outhouse, 1974).

Sire Breed Effects on Market Lambs. How did the Suffolk (S), Hampshire (H), and Oxford (O) sires of market lambs compare? Surprisingly, survival to 10-week weaning was better for lambs by Oxford than by Hampshire or Suffolk sires (67, 61, and 56%, Table 9). Lambs by Suffolk, Hampshire, and Oxford sires ranked in descending order in weight at birth, weaning, 22, and 31 weeks (112, 109, and 105 lb at 31 weeks, respectively). This live weight ranking is repeated for age-constant carcass weights and in estimated weights of boneless cuts per lamb (24.5 lb for S, 23.5 for H, and 22.5 for O) as well, because differences were small in dressing % and compensatory in leg conformation, backfat, and kidney fat. When sire-breed effects on lamb survival, growth, and composition were combined

Table 6.—Estimated yield of boneless lamb per ewe exposed for Finn (F_x) and Rambouillet (R_x) cross and purebred (P) ewes from 7 breeds of dam[1]

Breeding of ewe	Age of ewe (years)	Number of ewes exposed	Lambs 100 ewes exposed: Born alive	Weaned[1]	Boned yield lamb (lb)	Boneless lamb ewe exposed if Born alive = marketed (lb)	(pct)	Weaned = marketed (lb)	(pct)
F_x	1	315	122.0	63.1	21.96	26.8	(171)	13.9	(154)
R_x	1	206	67.7	38.9	23.15	15.7	(100)	9.0	(100)
P	1	301	57.7	28.3	22.18	12.8	(82)	6.3	(70)
F_x	2	293	164.6	104.5	21.55	35.5	(134)	22.5	(122)
R_x	2	193	116.4	81.2	22.74	26.5	(100)	18.5	(100)
P	2	54	107.7	66.2	22.18	23.9	(90)	14.7	(80)
F_x	3	284	168.5	123.2	23.97	40.4	(110)	29.5	(108)
R_x	3	190	150.4	111.1	24.52	36.9	(100)	27.2	(100)
P	3	76	121.4	86.0	24.72	30.0	(81)	21.3	(78)
F_x	4	84	202.1	158.2	25.22	51.0	(167)	39.9	(158)
R_x	4	46	115.6	95.5	26.43	30.6	(100)	25.2	(100)
P	4	44	126.8	105.9	25.70	32.6	(107)	27.2	(108)
F_x	Mean[2]	976	**159**	**105**		**36.6**	**(136)**	**24.5**	**(127)**
R_x	Mean	635	112	80		27.0	(100)	19.2	(100)
P	Mean	475	100	67		23.7	(88)	16.0	(83)

[1]Lambs are crossbreds from ewes born in 1970 and 1971 sired by Suffolk, Hampshire, and Oxford rams, born in spring 1971 through 1974 and weaned at about 10 weeks of age (Dickerson, 1974).

[2]Mean gives equal weight to each age of ewe and lambing year. Means set in boldface are extremes for significant breed differences.

Table 7.—Performance of ewe and wether market lambs from Finn and Rambouillet cross and purebred ewes by breed of ewes' dam[1]

Trait		Lamb numbers	Dam of ewe: Suffolk	Hampshire	Dorset	Rambouillet	Targhee	Corriedale	Significance[2]
Alive:	percent	2,653							
At birth			90.0	**98.0**	**97.0**	**97.0**	**97.0**	**97.0**	<0.001
To 4 weeks			60	68	**77**	**78**	**77**	**79**	<.001
To 10 weeks			51	54	**65**	**65**	**65**	**61**	<**.01**
Weight:	lbs								
At birth		[1]1,631	8.4	**8.7**	8.2	**9.3**	**9.0**	**9.1**	<.001
At 10 weeks		1,631	36	34	35	38	37	35	>.20
At 22 weeks		1,528	84	82	81	83	83	82	>.50
At 31 weeks (slaughter)		1,541	110	106	108	111	109	108	<.10
Daily gain 10 to 31 weeks	lbs	1,528	.55	.54	.51	.54	.53	.52	>.10
Carcass:		1,541							
Weight	lbs		55.5	54.2	54.9	55.6	54.4	53.6	>.25
Dressing	percent		**50.6**	**50.8**	**50.5**	49.7	49.3	49.2	<.001
Grade:[3]									
Quality			11.7	**12.4**	**12.3**	11.7	11.6	11.7	<.001
Leg conformation			**12.6**	**12.6**	**12.8**	11.8	11.9	11.8	<.001
Kidney fat	percent		**3.9**	**3.9**	**3.9**	4.2	4.3	4.5	<.001
Backfat	inch		**.27**	.32	.30	**.25**	.28	**.33**	<.001
Yield grade[4]			**3.8**	4.1	4.0	**3.8**	4.0	4.4	<.001
Estimated boneless cuts[3]	percent		**43.6**	43.1	43.3	**43.6**	43.4	42.7	<.001
	lbs.		**24.1**	23.2	23.6	**24.1**	23.4	22.7	<.001
Estimated trimmed cuts[4]	percent		**74.5**	**74.2**	**74.0**	**74.1**	73.6	73.0	<.001
	lbs		**41.0**	39.8	40.2	**40.7**	39.6	38.7	<.001

[1]Crossbred lambs from 1970 and 1971 ewes lambing in spring 1971 through 1974 by Suffolk, Hampshire, and Oxford sires (Dickerson, 1974). Each lambing year was given equal weight. Birth weights are for lambs surviving to weaning
[2]Means set in boldface are extremes for statistically significant breed differences
[3]Grades and boneless cuts as in Table 1
[4]Yield grade and estimated trimmed cuts as in Table 5.

Table 8.—Estimated lamb numbers and boneless lamb production for breed of dam of ewes lambing at 1 through 4 years of age[1]

Breed of ewes' dam	Number of ewes	Lambs/100 ewes exposed: Born alive	Weaned	Boneless yield lamb (lb)	Estimated boneless lamb cuts/ewe exposed year if— —: Born alive = marketed (lb) (pct)	Weaned = marketed (lb) (pct)
Suffolk	270	**131**	**84**	24.1	31.5 **(114)**	20.3 **(106)**
Hampshire	373	110	64	23.2	25.5 (93)	14.8 (77)
Dorset	409	**124**	**89**	23.6	29.2 **(106)**	21.1 **(110)**
Rambouillet	332	114	**80**	24.1	27.6 **(100)**	19.2 **(100)**
Targhee	444	116	**84**	23.4	27.1 **(98)**	19.6 **(102)**
Corriedale	389	111	72	22.7	25.2 (92)	16.3 (85)

[1]Ewes are ½ Finn, ½ Rambouillet, or purebred, born in spring 1970 and 1971 and producing crossbred lambs in 1971 through 1974 by Suffolk, Hampshire, and Oxford rams (Dickerson, 1974 and 1975) at MARC. Weaning was at 10 weeks of age. Means set in boldface are extremes for statistically significant breed differences

(Table 10), the higher lamb survival for Oxford sires more than offset the advantage of Suffolk sires in growth and yield of boned cuts per lamb; and Hampshire-sired lambs were intermediate. If most lambs born alive are reared, Suffolk sires may well have a 3 to 6% advantage over Hampshire or Oxford sires; but under conditions of high lamb mortality, the breed of sire ranking may be reversed.

Table 9 on next page.

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Table 10.—Estimated efficiency in boneless lamb production for breed of sire of lambs from ewes lambing at 1 through 4 years of age[1]

Breed of sire	Number of lambs	Lambs born: Alive (pct)	Weaned (pct)	Boneless yield/lamb (lb)	Estimated boneless cuts/lamb born if— —: Born alive = marketed (lb) (pct)	Weaned = marketed (lb) (pct)
Suffolk	548	95	56	**24.5**	**23.3** (100)	13.1 (100)
Hampshire	600	96	61	23.5	22.5 (97)	13.7 (105)
Oxford	720	97	**67**	22.5	21.8 (94)	**14.6** (112)

[1]Ewes are ½ Finn, ½ Rambouillet, or purebred born in spring 1970 and 1971 and producing crossbred lambs in 1971 through 1974 by Suffolk, Hampshire, and Oxford rams (Dickerson, 1974 and 1975) at MARC. Weaning was at 10 weeks of age. Means set in boldface are extremes for statistically significant breed differences.

Table 9.—Breed of sire effects on performance of ewe and wether market lambs from Finn and Rambouillet cross and purebred ewes[1]

Trait		Lamb numbers	Sire of lamb: Suffolk	Hampshire	Oxford	Significance[2]
Alive:	percent	3,184				
At birth			95.0	96.0	**97.0**	<0.05
At 4 weeks			70	74	**77**	<.01
At 10 weeks			56	61	**67**	<.01
Weight:	lbs					
At birth		[1]1,997	**9.1**	8.8	8.6	<.001
At 10 weeks		1,997	**37.8**	36.0	34.0	<.001
At 22 weeks		1,855	**86.5**	83.3	78.4	<.001
At 31 weeks (slaughter)		1,868	**112.4**	108.9	105.2	<.001
Daily gain 10 to 31 weeks	lbs	1,855	.56	.53	.50	<.001
Carcass:		1,868				
Weight	lbs		**56.7**	55.0	52.6	<.001
Dressing	percent		**50.2**	**50.1**	49.6	<.02
Grade[3]						
Quality			11.7	**12.0**	**11.9**	<.05
Leg conformation			12.0	**12.4**	12.0	<.001
Kidney fat	percent		4.4	4.2	**3.9**	<.001
Backfat	inch		**.26**	.31	.31	<.001
Yield Grade[3]			**3.9**	4.2	4.1	<.001
Estimated boneless cuts[3]	percent		**43.5**	43.0	43.2	<.001
	lbs		**24.5**	23.5	22.5	<.001
Estimated trimmed cuts[3]	percent		73.8	73.6	73.9	<.50
	lbs		**41.5**	29.9	38.4	<.001

[1]Crossbred lambs from 1970 and 1971 ewes lambing in spring 1971 through 1974 by Suffolk, Hampshire, and Oxford sires, (Dickerson, 1974). Each lambing year was given equal weight. Birth weights are for lambs surviving to weaning
[2]Means set in boldface are extremes for statistically significant breed differences.
[3]Carcass grades, yield grade, and estimated cut yields as in Table 7.

PUREBRED PERFORMANCE OF SELECTED BREEDS

Gordon E. Dickerson[1] and Hudson A. Glimp

Summary

A 4-year comparison of performance of purebred Suffolk (S), Hampshire (H), Dorset (D), Rambouillet (R), Targhee (T), and Corriedale (C) indicated real differences in traits that would affect their usefulness in production of purebred or crossbred market lambs. When Suffolk ewe performance equaled 100, the breed ranking of ewes producing purebred lambs was S (100), T (95), H (91), R (91), and C (84). However, when purebred ewes produced crossbred lambs by the same sire breed the breed ranking was D (104), T (104), S (100), R (100), H (98), and C (98). These results suggest the use of Dorset, Suffolk, and Targhee ewes for crossbred spring lamb production and Rambouillet under adverse lambing-rearing conditions.

Introduction

Effective industry utilization of genetic variation to reduce costs of market lamb production requires reasonably reliable information about breed differences in performance characteristics. Performance as purebreds is important (1) for costs of producing purebred breeder replacements and by-product market animals and (2) in predicting their place in commercial crossbreeding and adaptability to alternative systems of market lamb production and marketing.

Early research with sheep at MARC focused on purebred performance for representative samples of three meat breeds (Suffolk, Hampshire, and Polled Dorset) and of three whitefaced breeds (Rambouillet, Targhee, and Corriedale).

Methods

This study included about 1,300 ewes exposed to rams each fall in 1968, 1969, 1970, and 1971. Breeding stock was assembled at MARC from 1966 to 1969 as described by Glimp (1971) and Dickerson *et al.*, (1972).

All 1968 fall matings were intrabred in single sire drylot pens, but both purebred and crossbred matings in single- and multiple-sire pens were represented in the falls of 1969, 1970, and 1971.

Results and Discussion

Results for purebred lamb performance for 4 years (Table 1) emphasize a number of breed differences. Livability under adverse spring lambing-rearing conditions (i.e., chilling and other environmental stress) was better for Hampshire, Rambouillet, and Targhee than for Suffolk, Dorset, and Corriedale.

Except for Corriedale, weight at birth was closely predictive for weight at 10 weeks (weaning) and at 22 weeks of age. Suffolk were easily largest, Hampshire, Rambouillet, and Targhee intermediate, and Dorset smallest. Corriedale were large at birth but weighed less than all but Dorset at weaning and 22 weeks of age. Age-constant live weight at slaughter followed the same ranking.

The meat breeds (Suffolk, Hampshire, and Dorset) were definitely superior in dressing percent and carcass grades for quality and conformation. Meat breed and Rambouillet carcasses had less kidney fat. Suffolk, Dorset, and Rambouillet had the least fat cover over the rib eye (backfat). Rib eye (muscle) area was largest in Suffolk and Hampshire, smallest in Corriedale.

Estimated yield of boneless trimmed cuts was nearly 1% higher for meat breeds and Rambouillet than for Targhee and Corriedale. Thus, estimated weight of boneless trimmed cuts per lamb was highest for Suffolk (29 lb), intermediate for Hampshire, Rambouillet, and Targhee (25 to 24 lb), and lowest for Dorset and Corriedale (22 lb).

Breed differences in purebred ewe performance (Table 2) were negligible in fertility (percent lambed/exposed) but important for lambs born/ewe lambing and for ewe size. Lambs born/100 ewes lambing were 161 for Suffolk, 155 for Dorset, and 152 for Targhee. However, breed differences in lamb mortality caused the least prolific Rambouillet (104) to rank

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Table 1.—Purebred lamb performance of some domestic breeds

Trait		Total numbers	Breeds: Suffolk	Hampshire	Dorset	Rambouillet	Targhee	Corriedale	Significance[1]
Alive at 10 weeks	percent	[2]4,989	64.0	69.0	66.0	**72.0**	71.0	64.0	<0.01
Ram weight	lbs	[3]713							
At birth			**11.2**	10.4	9.0	10.4	10.6	10.8	<.01
At 10 weeks			**51.8**	45.6	39.7	47.6	48.7	44.3	<.01
At 22 weeks			**118**	105	89	104	105	98	<.01
Ram carcass weight	lbs	[4]517	**63**	55	46	51	53	48	<.01
Dressing	percent		**52.5**	**52.0**	**52.2**	48.5	49.9	49.1	<.01
Grade:[5]									
Quality			**12.0**	**12.7**	**12.2**	10.4	10.5	10.5	<.01
Carcass conformation			**12.6**	**13.3**	**12.8**	10.8	11.1	11.2	<.01
Leg conformation			**13.2**	**13.7**	**13.2**	11.0	11.2	11.3	<.01
Kidney fat	percent		**2.7**	**2.7**	**2.5**	**2.7**	3.2	3.3	<.05
Back fat	inches		**.13**	.17	**.11**	**.13**	.16	.19	<.01
Rib eye area	inches[2]		**2.4**	2.2	2.1	2.0	1.9	1.7	<.01
Estimated boneless cuts[6]	percent		**46.2**	**46.0**	**46.5**	**46.1**	45.6	45.1	<.01
	lbs		**29.2**	**25.1**	21.7	23.5	23.9	21.6	<.01

[1]Means set in boldface are extremes for statistically significant breed differences.
[2]Percent weaned of total born for ewes lambing in spring of 1969-1972, inclusive, at MARC (Dickerson and Glimp, 1975).
[3]Ram lambs reared in spring of 1969 and 1970 at MARC (Dickerson *et al.*, 1972).
[4]Mean for 24 and 26 week ages at slaughter
[5]Grades from 7 = low good; to 15 = high prime.
[6]Estimated percent boneless major cuts = 47.8 - 11.8 (backfat in) - .44 (pct kidney fat) + .092 (leg conformation) (USDA, 1969).

Table 2.—Purebred ewe performance of some domestic breeds[1]

Trait		Total numbers	Suffolk	Hampshire	Dorset	Rambouillet	Targhee	Corriedale	Significance[1]
			Breeds						
Lambed/exposed	percent	6,136	82.0	82.0	83.0	77.0	83.0	82.0	>0.05
Lambs/ewe lambing	percent	4,989							
At birth			**161**	146	155	144	152	148	<.01
At 4 weeks			**121**	108	113	114	**124**	115	>.10
At 10 weeks			**103**	99	**102**	**104**	**108**	94	>.20
Ewe size[2]	percent	1,300	**100**	86	75	94	**97**	91	<.001
Estimated ewe cost/year[3]	percent		**100**	91	84	96	**98**	94	<.001
Clean wool/ewe/year[4]	lbs		3.3	2.9	3.3	4.6	5.3	**6.2**	
Ewe efficiency[5], percent, for purebred lambs alive:									
At birth			100	87	89	81	87	82	
At 10 weeks			100	91	91	91	95	84	
crossbred lambs alive:									
At birth			100	93	**103**	89	95	94	
At 10 weeks			100	98	**104**	**100**	**104**	96	

[1]Ewes exposed to rams for 1969 to 1972 spring lambing at MARC (Dickerson and Glimp, 1975). Means set in boldface are extremes for statistically significant breed differences
[2]At beginning of 1971 fall breeding, as percent of Suffolk.
[3]Ewe cost = 100 - 2/3 (100 - relative ewe size).
[4]From literature (Dickerson and Glimp, 1975).
[5]Efficiency = (lambs/ewe lambing) (lb boneless cut/lamb) + (lb clean wool/ewe) /(relative ewe cost), as percent of Suffolk ewe efficiency.

with Suffolk and Dorset (102 to 104) and approached Targhee (108) in lambs weaned/ewe lambing at 10 weeks. Thus, ranking of breeds for prolificacy may depend on degree of control of lamb mortality.

Value of wool (clean wool/ewe/year) and ewe size also affect net ewe efficiency. Expected net ewe efficiency in production of boneless lamb and clean wool under ideal conditions for saving spring lambs born (all lambs born alive being weaned) was highest for Suffolk, about 12% lower for Hampshire, Dorset, and Targhee, and 18% lower for Rambouillet and Corriedale (ignoring the accelerated lambing potential of Dorset and Rambouillet). When numbers actually weaned at 10 weeks were used, Suffolk still had a 5% advantage over Targhee and 9% or more over the other breeds.

If purebred ewes of different breeds are used to produce crossbred lambs by the same breed of sire, transmitted dam breed effects on boneless trimmed cuts per lamb are cut in half. Then Suffolk or Dorset dams would be most efficient based on lambs born, but for numbers reared, Dorset and Targhee would be most efficient and Suffolk and Rambouillet intermediate. These results suggest use of Dorset, Suffolk, and Targhee ewes for crossbred spring lamb production and Rambouillet under the more adverse conditions. Dorset and Rambouillet would have the additional advantage of a longer breeding season for accelerated lambing programs (Outhouse, 1974).

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MATERNAL BREED DEVELOPMENT PROJECT

Larry D. Young[1] and Gordon E. Dickerson

Summary

The Maternal Breed Development project was initiated to determine the usefulness of maternal multi-breed populations relative to the contributing pure breeds as female parents in market lamb production and to develop selection criteria and procedures for improving maternal populations. The project utilizes flocks of Dorset (D), Finnsheep (F), Rambouillet (R), Suffolk (S), Targhee (T), Composite I (½F¼D¼R) and Composite II(½F¼S¼T). Data from this project will appear in later progress reports.

Introduction

The wide genetic differences in rate of reproduction among existing breeds of sheep emphasize the very large potential for reduction in the costs of producing market lambs if specialized maternal stocks can be developed for use in terminal crossbreeding systems. There are at least three basic ways to develop specialized maternal stocks: (1) selection within the more promising existing pure breeds, (2) production of a crossbred ewe by crossing the more promising pure breeds, and (3) development of new breeds from a crossbred foundation.

Data from the Germ Plasm Evaluation project at MARC and other experiments (Dickerson, 1975, 1977) provide a basis for choosing breeds and crosses with the greatest potential as maternal stocks. Important questions remain regarding the potential usefulness of new composite breeds versus crossbreeding of existing breeds and the development of effective selection procedures for further improvement of maternal performance. These questions will be addressed in the Maternal Breed Development project.

Rationale

Substantial heterozygosity can be maintained in composite populations. If heterosis is maintained in direct proportion to heterozygosity, then new composite breeds based on crossbred foundations would have several advantages relative to alternative crossbreeding systems. One advantage of a composite breed is that, subsequent to the breed formation stage when the initial F_1 crosses are made, the population has the same management requirement as straightbreeding. Therefore, it may be especially well suited for use by producers who have limitations on flock size, numbers of breeding pastures, and other resources necessary to manage a rotational crossbreeding system. In the formation of composite populations, existing breeds differing widely in characteristics such as litter size, body size, milk production, and carcass characteristics can be used. By careful selection of breeds, it is hoped that composite breeds can be developed to fit production systems that vary in level of intensification. In addition, a composite population should have more genetic variability and a higher selection intensity due to a higher reproductive rate; both of which should allow for greater intrapopulation selection response.

The Maternal Breed Development project is designed to utilize the genetic differences between breeds for the economically important reproductive traits of age at puberty, length of breeding season, and litter size. The objectives of this project are to determine the usefulness of maternal multi-breed populations relative to the contributing pure breeds as female parents in market lamb production and to develop selection criteria and procedures for improving maternal populations. The ewes in this project are managed under two systems that are applicable to different levels of feed and labor resources. One system is the conventional annual lambing system with ewes exposed to rams in November. This system was included since labor and feed resources will continue to be seasonal even for some producers who are willing to raise sheep under semi-intensive confinement programs. The second system incorporates an accelerated 8-month lambing schedule, which would allow a producer to more optimally utilize confinement facilities and year-around labor. Ewes are exposed to fertile rams in April, August, and December under this system, giving each ewe an opportunity to lamb every 8 months.

Procedure

This experiment was initiated with the August 1975 breeding season. During that season, matings were made to produce the F_1 lambs in the Composite I and Composite II flocks. The first phase of this experiment is scheduled for completion with the Fall 1980 breeding season. This phase has been concerned with developing the Composite populations to the F_3

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Table 1.—Number of lambs born in each season by breed type

Lamb breed type	Lambing season: 1976 Jan	1976 May	1976 Sept	1977 Jan	1977 May	1977 Sept	1978 Jan.	1978 March	1978 May	1978 Sept.	1979 Jan.	1979 March	1979 May	1979 Sept	1980 Jan.	1980 March	1980 May
Synthetic I:																	
F_1	213	158	40	189	127	37	—	—	—	—	—	—	—	—	—	—	—
F_2	—	134	20	124	277	20	142	313	48	77	203	304	156	4	—	—	—
F_3	—	—	—	—	—	—	35	—	151	15	109	109	213	30	303	—	245
Synthetic II:																	
F_1	153	310	45	226	239	119	—	313	—	—	—	—	—	—	—	—	—
F_2	—	—	—	30	106	21	—	358	—	—	—	340	—	—	—	147	—
F_3	—	—	—	—	—	—	—	—	—	—	—	146	—	—	—	299	—
Rambouillet	197	140	50	274	141	42	94	—	48	19	158	110	63	5	51	—	108
Dorset	178	95	36	169	135	24	155	—	158	62	166	—	143	28	215	—	142
Targhee	67	41	6	66	82	9	—	103	—	—	—	110	—	—	—	101	—
Finn	221	388	74	321	503	92	167	—	225	44	239	357	341	52	88	543	212
Suffolk	—	—	—	—	—	—	—	—	—	—	—	96	—	—	—	145	—

stage, increasing the size of the purebred flocks, and developing selection criteria and procedures. The number of lambs born in each flock are presented in Table 1 for each lambing season. The numbers of lambs in the Composite I and Composite II flocks are given for the F_1, F_2, and F_3 generations. During the first six seasons, all flocks were maintained under the accelerated lambing program in order to monitor out-of-season lambing performance. In the Fall of 1977, the Composite II and Targhee flocks and part of the Composite I, Rambouillet, and Finnsheep flocks were moved to the annual lambing program. In the 1977 annual breeding season, the Rambouillet and Finnsheep flocks were used in other experiments and the lambing results are not included here. A Suffolk population was also added to the annual lambing program in the Fall of 1977. In the Fall of 1979, the Composite I and Rambouillet flocks were dropped from the annual lambing program. The data from this phase is not yet complete.

The Fall 1981 breeding seasons should be the base generation for the selection phase of the project. During the selection phase of the annual lambing program, populations of Finnsheep, Suffolk, Targhee, and Composite II ewes will be selected to improve the number of lambs produced per ewe per year. The Composite II flock was established by mating Finnsheep-Suffolk crossbred ewes and rams to Finnsheep-Targhee crossbred ewes and rams, which resulted in a population of animals consisting of ½ Finnsheep, ¼ Suffolk, and ¼ Targhee breeding. Selection emphasis will be on improving age at puberty, mothering ability, and litter size. Unselected populations of Finnsheep and Composite II ewes will be maintained in order to monitor selection progress.

During the selection phase of the accelerated lambing program, populations of Dorset, Finnsheep, Rambouillet, and Composite I ewes will be selected to increase the number of lambs produced per ewe per year. The Composite I flock was established by mating Finnsheep-Rambouillet crossbred ewes and rams to Finnsheep-Dorset crossbred ewes and rams which resulted in a population of animals consisting of ½ Finnsheep, ¼ Dorset, and ¼ Rambouillet breeding. Considerable emphasis will be placed on improving out-of-season breeding as well as age at puberty, mothering ability, and litter size. Unselected populations of Dorset and Composite I ewes will be maintained to allow measurement of selection response. Data from this project will be presented in later progress reports.

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PHYSIOLOGY AND REPRODUCTION

FACTORS INFLUENCING LAMB PERFORMANCE

Bruce D. Schanbacher[1], John D. Crouse, and Calvin L. Ferrell

Summary

Growth and performance of young market lambs are affected by sex condition. Ram lambs grow more rapidly and efficiently than ewe lambs; however, castration abolishes this effect. The male hormone, testosterone, has been shown to be responsible for the sex effect on lamb performance.

Performance of growing-finishing lambs is also affected by the environment. In particular, photoperiod (daylength) has been shown in recent experiments to be a major environmental factor in the regulation of lamb growth. The beneficial (positive) effects of long photoperiods and ability to lengthen the day with supplemental lighting provide the incentive to maximize lamb performance via environmental management. Results of these studies are aimed at identifying those biological and environmental factors that can be manipulated to improve production efficiency of market lambs.

Introduction

Exploitation of the biological efficiency inherent in the young market lambs has yet to be realized. Although it has been recognized for some time that sheep are extremely efficient converters of most feedstuffs to edible lean tissue, little attention has been paid to those biological and environmental factors that influence lamb productivity. Two factors shown to have dramatic influences on efficiency of lamb production include sex condition and photo-environment. The results given are from research aimed at these biological and environmental factors that can be manipulated to improve production efficiency of market lambs.

Results

Sex Condition. Hormones secreted by the testis of domestic species are known to have significant effects on growth rate and feed utilization. The effects of shortened scrotums and castration on testosterone secretion and lamb performance were evaluated in a study with Finn-crossbred lambs. Some of the responses to treatment are listed in Table 1. Serum testosterone in short scrotum and intact rams was similar, whereas castration resulted in considerably lower concentrations of this steroid. Serum luteinizing hormone, on the other hand, was increased threefold in short scrotum rams and twelvefold in wethers as compared to that of intact rams. Post-weaning average daily gain and feed efficiency were highest in intact and short scrotum rams and these groups had heavier carcasses and better yield grades than wethers. Quality grades were similar. The beneficial responses were assumed to be attributable to the high-serum concentrations of testosterone.

Testosterone Influences. Because testicular hormones other than or in addition to testosterone may be responsible for the differences in performance of intact and castrate lambs, an experiment was conducted with castrate lambs treated with physiological doses of testosterone. Growth rate, efficiency of feed utilization, and carcass yield of intact ram lambs and testosterone-treated wethers were superior to the corresponding traits of wethers (Table 2). Wethers, however, had greater backfat thickness and percentage kidney and pelvic fat, and their carcasses graded higher than those of ram lambs or wethers implanted with a high dosage of testosterone (Table 3). Carcass water and protein were not significantly affected by treatment; however, carcass fat and gross energy were highest for wethers and lowest for intact rams (Table 4). The relationship between testosterone and carcass fat and energy was dose dependent; i.e., decreased fat and energy were associated with increased serum testosterone. In conclusion, testosterone appears to be the principal testicular hormone responsible for the superior performance and preferred carcass traits characteristic of young market rams.

Photoperiod Influences. The effects of photoperiod on performance of the growing-finishing lamb have been evaluated in an experiment with 24 rams and 24 wethers. Half of the rams and half of the wethers were placed in a controlled environment and exposed to long photoperiods (16 hr light:8 hr dark) while the remaining rams and wethers were placed in a similar environment but exposed to short photoperiods (8 hr light:16 hr dark). All lambs were caged in groups of two and fed a pelleted ration *ad libitum* for the duration of the study (10 to 22 weeks of age). Performance and carcass data showed that both photoperiod and sex of

Table 1.—Selected hormonal and performance traits of sexually altered rams

Sex	No	LH (ng ml)	Testosterone (ng ml)	Avg daily gain (lb/day)	Carcass weight (lb)	Quality grade[1]	Yield grade[2]
Ram	45	1.21±1.43	1.94±0.30	0.569±0.022	59.84±2.42	11.4±0.5	3.3±0.2
Short scrotum	46	3.54±1.35	2.12± .28	.547± .022	56.98±2.20	11.2± .5	3.1± .2
Wether	39	14.29±1.38	.01± .29	.468± .022	52.14±2.20	11.8± .5	3.6± .2

[1]Quality grade: 10 = low choice, 11 = avg choice; 12 = high choice.
[2]Yield grade 1 = high cutability, 5 = low cutability

Table 2.—Average daily gain, dry feed intake and utilization of metabolizable energy (ME) by ram (R), wether (W) and testosterone-treated [low (W_L), intermediate (W_I), and high (W_H)] wether lambs

Group	Avg daily gain (lb/day)	Total dry feed intake (lb)	Total ME intake (Mcal)	Dry feed per gain (lb/lb)	ME per gain (Mcal/lb)
R	0.752	239.8	316	3.8	5.045
W	.451	266.2	348	4.3	5.681
W_L	.616	266.2	350	4.3	5.590
W_I	.699	246.4	322	3.9	5.090
W_H	.569	253.0	332	4.1	5.318
S.E.	.068	19.8	25	.4	.545
Level of significance	$P<.05$	$P<.05$	$P<.05$	$P<.10$	$P<.10$

[1]Bruce D. Schanbacher is a reproductive physiologist at MARC.

lamb affected growth rate and feed efficiency, but that carcass quality and yield were only affected by sex of lamb. A sex by photoperiod interaction was not observed for any of the traits measured. Mean±SEM for performance and carcass traits are presented in Tables 5 and 6. Carcass weight, like slaughter weight, was affected by photoperiod and sex of lamb with rams exposed to long photoperiods having the heaviest carcasses and wethers exposed to short photoperiods having the lightest carcasses. Ram carcasses were leaner, had better yield grades, and were heavier than wether carcasses, but ram and wether carcasses both graded choice. While testosterone is assumed to be responsible for the superior performance of ram lambs, the hormonal mechanism(s) responsible for the superior performance of lambs exposed to long photoperiods is being assessed.

Table 3.—Carcass characteristics of ram (R), wether (W), and testosterone-treated [low (W_L), intermediate (W_I), and high (W_H)] wether lambs

Group	Adjusted backfat thickness (in)	Kidney and pelvic fat (pct)	Quality grade[1]	Yield grade[2]
R	0.188	2.91	9.98	1.60
W	.271	4.01	11.21	1.84
W_L	.248	3.12	10.47	1.81
W_I	.200	4.13	10.22	1.68
W_H	.181	4.13	9.97	1.60
S.E.	.019	.29	.25	.07
Level of significance	P<.05	P<.01	P<.01	P<.05

[1]Quality grade: 10 = low choice; 11 = avg choice; 12 = high choice.
[2]Yield grade: 1 = high cutability; 5 = low cutability.

Table 4.—Carcass weight and composition of ram (R), wether (W), and testosterone-treated [low (W_L), intermediate (W_I), and high (W_H)] wether lambs

Group	Weight (lb)	Water (lb)	Fat (lb)	Protein (lb)	Ash (lb)	Energy (Mcal)
R	48.84	27.28	12.32	7.48	1.694	72
W	50.16	26.84	14.30	7.26	1.672	80
W_L	49.72	27.28	13.42	7.48	1.584	76
W_I	49.28	27.06	12.98	7.70	1.672	75
W_H	47.74	27.06	11.66	7.48	1.650	69
S.E.	1.76	1.54	1.32	.44	.132	5
Level of Significance	P<.05	N.S	P<.01	N.S	N.S	P<.01

Table 5.—Least squares means for performance traits of growing-finishing lambs

Treatment[1]	Avg daily gain (lb/day)	Feed efficiency (lb feed/lb gain)	Final weight (lb)	Carcass weight (lb)
Ram (16L:8D)	0.902±0.031	4.3±0.1	129.36±2.64	69.96±1.32
Ram (8L:16D)	.748± .031	4.5± .1	117.04±2.42	62.48±1.32
Wether (16L:8D)	.759± .031	4.6± .1	117.48±2.64	65.56±1.32
Wether (8L:16D)	.660± .031	4.8± .1	109.34±2.42	60.28±1.32

[1](16L:8D) refers to exposure to long days (16 hr light/24 hr). (8L:16D) refers to exposure to short days (8 hr light/24 hr)

Table 6.—Least squares means for carcass traits of growing-finishing lambs

Treatment[1]	Backfat thickness (in)	Kidney pelvic fat (pct)	Quality grade[2]	Yield grade[3]
Ram (16L:8D)	0.208±0.031	2.8±0.3	10.6±0.3	1.4±0.2
Ram (8L:16D)	.196± .023	2.6± .2	10.8± .2	1.3± .2
Wether (16L:8D)	.464± .023	3.2± .2	11.2± .2	1.8± .2
Wether (8L:16D)	.240± .027	3.2± .3	11.4± .2	1.6± .2

[1](16L:8D) refers to exposure to long days (16 hr light/24 hr). (8L:16D) refers to exposure to short days (8 hr light/24 hr).
[2]Quality grade: 10 = low choice; 11 = average choice and 12 = high choice.
[3]Yield: 1 = high cutability; 5 = low cutability.

PHYSIOLOGY AND REPRODUCTION

OUT-OF-SEASON BREEDING

Sherrill E. Echternkamp[1], Ronald K. Christenson[1], Danny B. Laster[2], Donald D. Lunstra[1], and Bruce D. Schanbacher[1]

Summary

Acceptable lambing rates were achieved in seasonally anestrous ewes given two injections of pregnant mares serum gonadotropin (PMSG) at 16-day intervals when the first PMSG injection was preceded by 8 to 16 days of intravaginal progestogen treatment. Factors affecting lambing response were breed of sheep, interval from PMSG injection to onset of estrus, ovulation rate, number of viable spermatozoa in the oviduct of the ewes, ram aggressiveness and fertility, or a combination thereof. Exposure of a ram to an 8-hr photoperiod during the nonbreeding season increased libido and semen quality. If PMSG and progestogen pessaries were available to sheep producers, lamb production per ewe per year could be increased by utilizing the technology that has been developed.

Introduction

A variety of exogenous hormone treatments have been used in numerous investigations to induce estrus in ewes during seasonal anestrus. At MARC, studies have concentrated on using progestogen (Flurogestone acetate) impregnated pessaries and pregnant mares serum gonadotropin (PMSG). The success of this procedure has been variable; thus, our research has attempted to explain this variation and to develop recommendations that will maximize reproductive efficiency. The results of these studies are discussed in an effort to explain the contribution of the ewe and of the ram to the reduced lambing rates that are generally encountered with out-of-season matings.

Results

Ewe Studies. The feasibility of obtaining acceptable lambing rates in seasonally anestrous ewes treated with progestogen and PMSG was evaluated in experiment A utilizing 240 seasonally anestrous (April) and 449 cyclic (October) ewes. Breeds represented, number of ewes per breed, and number of ewes per treatment are listed in Table 1. The progestogen-PMSG treatment consisted of the insertion of an intravaginal progestogen pessary for 16 days, 10 mg of progesterone intramuscularly at pessary removal, and 750 IU of PMSG at 1 and 16 days after pessary removal. Rams were put with control and treated ewes at the time of pessary removal and remained with the ewes for 35 days. The seasonally anestrous ewes were at least 35 days postpartum and had weaned one or more lambs 14 days before the pessaries were inserted. The cyclic ewes (October) had weaned at least one lamb in the preceding June.

The treatment of anestrous ewes with progestogen-PMSG resulted in 63% of the ewes lambing compared to 16% for the non-treated ewes. Treatment had no significant effect on number of lambs born per ewe lambing. Treatment with progestogen-PMSG during the normal breeding season (October) increased ovulation rate (2.1 *vs* 1.9; $P<.05$). However, treatment did not improve conception rates or lambs born (Table 1). Percentage of ewes lambing was lower for April progestogen-PMSG treated ewes than for October control or progestogen-PMSG treated ewes (63% *vs* 84% and 86%, respectively). Breed differences were not significant.

Experiment B was initiated in June and involved 799 ewes representing the Rambouillet, Targhee, Hampshire, Dorset, Suffolk, Corriedale, Coarse Wool, and Finn-cross (1/2 Finn) breed groups. All ewes had lambed at least 35 days before the experiment was initiated and lambs had been weaned off. Treatment 1 was the non-treated control ewes. Treatment 2 consisted of insertion of an intravaginal progestogen pessary for 16 days, 10 mg of progesterone intramuscularly at pessary removal, and 750 IU PMSG subcutaneously 1 day after pessary removal. The treatment was repeated 8 days later. Treatment 3 was the same as treatment 2, except it employed a 1,000 IU dosage of PMSG instead of 750 IU. Control and treated ewes were put with rams at the time of first pessary removal and remained with the rams for 36 days. Number of ewes per breed, ovulation rate, and lambing performance for the three treatment groups are recorded in Table 2.

Breed had a significant effect on ovulation rate response ($P<.05$) to a given dosage level of PMSG and on percentage of ewes lambing in the progestogen-PMSG treated groups. Percentage of ewes lambing in the progestogen-PMSG treated groups for the different breeds were: Rambouillet, 26%; Targhee, 24%; Hampshire, 8%; Dorset, 34%; Suffolk, 8%; Corriedale, 17%; Coarse Wool, 40%; Finn-cross (1/2), 52%. Percentage of ewes lambing, lambs born per ewe exposed, and lambs born per ewe lambing were higher ($P<.01$) in the progestogen-PMSG treated than in the control ewes. Dosage of PMSG, 750 IU and 1,000 IU, had no significant effect on percentage of ewes lambing or lambs born per ewe lambing.

Experiment C examined the effects of duration of progestogen treatment on estrous response and fertility. February

Table 1.—Lambing performance of anestrous and estrous ewes treated with progestogen and PMSG

Month bred and breed	Number of ewes		Ewes lambing, percent		Lambs born per ewe exposed		Lambs born per ewe lambing	
	Control[1]	Treated[2]	Control[1]	Treated[2]	Control[1]	Treated[2]	Control[1]	Treated[2]
May:								
Rambouillet	40	20	25	55	0.38	1.15	1.20	1.82
Targhee	40	20	12	65	.18	.90	1.40	1.38
Hampshire	40	20	8	55	.10	1.00	1.33	1.82
Dorset	40	20	20	75	.30	1.00	1.88	1.53
Mean	160	80	16	63	.24	1.01	1.46	1.62
October:								
Rambouillet	43	38	93	95	1.47	1.29	1.58	1.36
Targhee	38	38	89	87	1.36	1.28	1.53	1.48
Hampshire	37	39	62	82	1.11	1.21	1.78	1.47
Suffolk	33	32	88	75	1.39	1.09	1.59	1.46
Corriedale	34	40	79	93	1.35	1.55	1.70	1.68
Coarse Wool	39	38	90	82	1.48	1.28	1.66	1.58
Mean	222	225	84	86	1.36	1.28	1.64	1.50

[1]Non-treated ewes.
[2]An intravaginal progestogen pessary (synchro-mate) was inserted for 16 days, 10 mg of progesterone was given intramuscularly at pessary removal, and 750 IU PMSG was given subcutaneously 1 and 16 days after pessary removal.

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Table 2.—Ovulation rate and lambing performance of anestrous ewes treated with progestogens and PMSG

Breed[2]	Number of ewes			Ovulation rate[1]		Ewes lambing, percent			Lambs born per ewe exposed			Lambs born per ewe lambing		
	[3] T_1	T_2	T_3	T_2	T_3	[3] T_1	T_2	T_3	[3] T_1	T_2	T_3	[3] T_1	T_2	T_3
Rambouillet	69	55	58	2.2±0.7	4.5±2.3	2	20	31	0.01	0.32	0.50	1.00	1.64	1.61
Targhee	29	23	22	1.4± .3	4.8±3.2	7	26	23	.07	.48	.36	1.00	1.83	1.60
Hampshire	74	65	59	1.3± .6	2.0± .5	0	6	10	.00	.12	.36	.00	2.00	1.17
Dorset	27	21	20	2.2±1.0	1.3± .5	4	24	45	.04	.29	.81	1.00	1.20	1.80
Suffolk	49	34	28	1.6±1.4	1.3±1.3	0	3	14	.00	.03	.21	.00	1.00	1.33
Corriedale	18	16	14	1.3± .2	2.4± .9	0	19	14	.00	.19	.14	.00	1.00	1.00
Coarse Wool	26	19	16	1.8± .5	2.3±1.3	0	32	50	.00	.37	.69	.00	1.17	1.38
Finnsheep-X (½)	26	15	16	3.3±1.4	2.7± .5	0	47	56	.00	.93	.88	.00	2.00	1.56
Mean	318	248	233	1.9± .4	2.6±1.0	2	22	30	.02	.34	.49	1.00	1.48	1.43

[1]Based on laparotomy of 7 ewes per subgroup with the laparotomy performed 8 to 13 days after the ewes were marked by fertile rams.
[2]Rambouillet, Hampshire, Dorset, and Suffolk ewes were bred to rams of their respective breed and Targhee, Corriedale, Coarse Wool, and Finnsheep-X ewes were bred to Finn rams.
[3]T_1 is control, non-treated ewes; T_2 is ewes treated with 750 IU of PMSG; and T_3 is ewes treated with 1,000 IU of PMSG.

and March lambing ewes (256 ewes) were assigned to a 38- or 73-day postpartum weaning group and within weaning group to a control, and 8- or 16-day progestogen treatment period. Treatment was an intravaginal progestogen pessary for 7 days after weaning in the 38-day weaned group or for 15 days beginning 8 days before weaning in the 73-day weaned group. Ewes received a 10 mg injection of progesterone on the day of pessary removal, followed by injections of 750 IU PMSG 1 and 16 days after pessary removal. Ewes were bred to Finn rams during April for the 38-day postpartum group and during May for the 73-day postpartum group.

Progestogen-PMSG treatment increased the incidence of behavioral estrus and lambing rate when compared to control ewes. During a 34-day breeding period, 96% of the progestogen-PMSG treated ewes exhibited estrus and 63% conceived. In comparison, 23% of the control ewes exhibited estrus and 5% conceived. Conception was not affected by length of progestogen treatment or days postpartum.

Experiment D involved the evaluation of breed and seasonal effects, and their interaction, on ovarian and pituitary response to progestogen-PMSG treatment. Finn and Hampshire ewes were treated with an intravaginal, progestogen pessary for 9 days, and 20 mg of progesterone and 500 IU of PMSG intramuscularly at pessary removal. Blood samples for determination of estradiol, progesterone, and luteinizing hormone (LH) concentration were collected. Additional anestrous Finn and Hampshire ewes were injected intramuscularly with 50 μg estradiol 17β in May and July and blood samples for determination of LH concentrations were collected.

Ovulation rate (Table 3), determined by laparoscopy on day 8, was higher for Finn than Hampshire ewes except in July when ovulation rate was decreased ($P<.05$) for Finn ewes. The interval from PMSG injection to preovulatory LH surge was affected ($P<.01$) by season with the longest interval in July (77.1±3.4 hr) and the shortest in November (56.5±1.4 hr). Finn ewes had higher preovulatory estradiol concentrations than Hampshire ewes at the November treatment and at the natural estrus in October. This is apparently related to the increased number of developing follicles in the Finn ewes.

A comparison of estrogen-mediated LH releases for May and July indicated that in Finn ewes the peak plasma LH concentration was decreased and the interval from estradiol-17β injection to LH surge was longer in July than May; whereas, in Hampshire ewes, the LH peak was increased in July and the interval was not affected by month. Thus, seasonal effects on reproduction in ewes appear to be mediated through gonadotropin secretion. These data suggest possible breed differences in intensity and timing of the seasonal changes in ewe fertility.

Experiment E evaluated spermatozoa transport, fertilization rate, embryo survival, and interval from onset of estrus to preovulatory LH surge in 30 cyclic Finn-cross (3/4) and in 30 progestogen-PMSG treated anestrous Finn-cross (3/4) ewes. The progestogen-PMSG treatment consisted of an intravaginal progestogen pessary inserted in the anterior vagina for 9 days, followed by an intramuscular injection of 20 mg of progesterone and 500 IU of PMSG at pessary removal. Estrus was continuously monitored beginning 2 days before expected estrus and continued until all ewes were detected in estrus. Jugular vein blood samples for LH determination were collected at 0, 2, 4, 6, 8, 10, 12, and 24 hr after onset of estrus. Conception and fertilization failure rates were determined at 48 hr after mating, 12 days after mating or at parturition.

The interval from onset of estrus to maximal preovulatory plasma LH concentration (Figure 1) was shorter ($P<.01$) for

Table 3.—Breed and seasonal effects on ovarian and pituitary response in Finn and Hampshire ewes[1]

Time	Interval from PMSG to LH surge (hr)	Peak estradiol concentration: Finn (pg/ml)	Hampshire (pg/ml)	Breed difference (pg/ml)	Ovulation rate: Finn	Hampshire	Breed difference
May	[3]64.8±2.2	[4,5]14.8±1.9 (5)	[4]12.8±1.7 (5)	2.0	[3]3.4±0.5	2.2±0.2	1.2*
July	[4]77.1±3.4	[5]11.2±1.0 (7)	[4]13.9±1.3 (7)	2.7	[4,6]2.0± .6	1.6± .2	.4
November	[5]56.5±1.4	[3]28.7±2.9 (6)	[3]20.5±1.4 (6)	8.2**	[3,7]3.0± .4	2.0± .3	1.0*
Control[2]		[4]17.8±2.8 (6)	[4]13.3±0.8 (7)	4.5*	[3,4]2.8± .4	1.6± .2	1.2**

[1]Number of animals composing a mean are in parenthesis. All three parameters were measured in the same ewes.
[2]Control group consisting of untreated cyclic ewes sampled from Day 14 through Day 5 (estrus = Day 0) in October.
[3,4,5,6,7]Mean differences within a column are indicated by different superscripts ([3,4,5] $P<.01$; [6,7] $P<.05$).
*Difference between breeds is significant ($P<.05$).
**Difference between breeds is significant ($P<.01$).

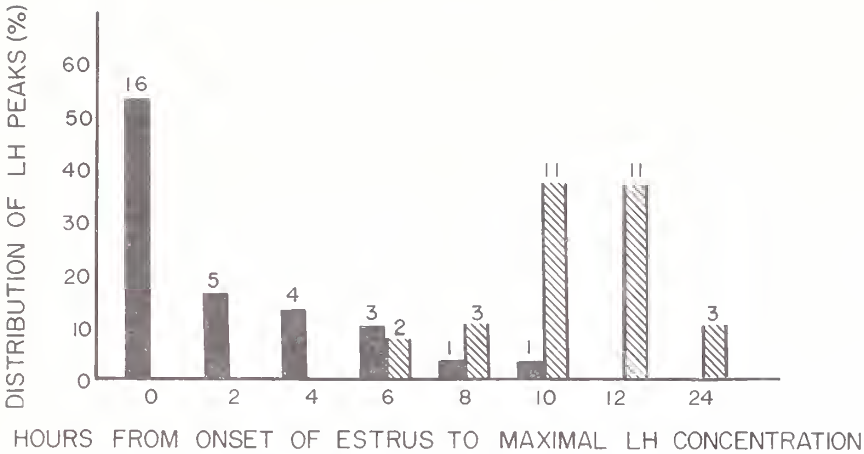

Figure 1—Percentage of cyclic ewes ( ) and progestogen:PMSG treated, anestrous ( ) with their peak plasma LH concentration occurring at the indicated times after onset of estrus. The number of ewes with an LH peak is listed at the top of the bar.

the out-of-season mated ewes than for the cyclic ewes. About 70% of the out-of-season mated ewes showed maximal LH concentration within 0 to 2 hr after onset of estrus; whereas 73.3% of the cyclic ewes had the maximal concentration at 10 to 12 hr after onset of estrus.

A comparison of conception rate, fertilization rate, and number of accessory spermatozoa per ovum for cyclic ewes and out-of-season mated ewes is presented in Table 4. The overall conception rate was 100% for the cyclic ewes and 76.6% for the out-of-season mated ewes. Fertilization rate, expressed as the percentage of fertilized ova or blastocysts per corpora lutea, was not affected by treatment. The number of accessory spermatozoa in the zona pellucida of the fertilized ova was fewer ($P<.01$) for the out-of-season mated ewes than for the cyclic ewes (5.5 *vs* 79.1). The decreased number of accessory spermatozoa for the progestogen-PMSG treated ewes may have resulted from the shorter interval from the onset of estrus to ovulation. Conception failure, rather than embryonic mortality, was the major cause of reduced fertility for the out-of-season mated ewes and, apparently, resulted from insufficient viable spermatozoa in the oviducts to fertilize the ova.

Experiment F examined relationships between estrous response, ovulation rate, and fertility in progestogen-PMSG treated ewes at two different times during the anestrous season. A total of 500 crossbred ewes were treated with progestogen pessaries for 16 days and injected with 750 IU PMSG at 1 and 16 days after pessary removal during either May-June or July-August.

Data accumulated from single-sire matings of 500 ewes indicated that estrous, ovulation, and lambing responses did not differ from ewes treated in May-June (92%, 2.5, 66%) compared to ewes treated in July-August (93%, 2.5, 67%). Estrous, ovulatory, and lambing responses were higher ($P<.05$) during the first PMSG induced period (76%, 3.0, 62%) than during the second (33%, 1.9, 43%) for May-June and July-August groups combined.

As intervals from PMSG injection to onset of estrus increased during both the first and second PMSG induced estrous periods, ovulation rate, marking intensity, and conception rate significantly declined, particularly in ewes with estrous onset 72 hr or more after PMSG injection. These results indicate that the reduction in lambing responses for progestogen-PMSG treated, anestrous ewes may be due to increased asynchrony of reproductive events in the ewe, decreased ram aggressiveness and/or fertility, or a combination thereof, as interval from PMSG injection to onset of estrous increases.

Ram Studies. Experiment G used five Finn and five Suffolk rams and evaluated seasonal changes in serum luteinizing hormone (LH), serum testosterone, and sexual activity and their possible interrelationships. Mating activity measurements and jugular vein blood samples were collected at 8-week intervals from October through October. Seasonal changes were observed for serum LH, testosterone (Figure 2), and for sexual activity (Figure 3). Mating activity in rams was highest for both breeds during the peak breeding season (October), and declined 50% by late spring and summer before it increased the next October. Likewise, sperm concentration and progressive motility were decreased during March, May, and July. Percentage of sperm acrosomes with normal morphology was highest in December and lowest in July (91.5 and 35% for Finns, 89.5 and 39.4% for Suffolk, respectively).

Serum LH concentrations were lowest in May and increased abruptly in July (.5 ng/ml *vs* 2+ ng/ml). Serum testosterone concentrations were highest during the October evaluation, decreased gradually through the winter months, and reached its lowest levels in late March. Thereafter, testosterone concentrations gradually increased to concentrations observed the previous fall. A positive relationship ($r=.59$) between mean testosterone and mating scores evaluated across months suggested that seasonal fluctuations in serum testosterone is associated with sexual behaviour of rams.

In experiment H, serum concentrations of reproductive hormones and spermatogenesis were studied in rams exposed to either decreasing (group 1) or increasing (group 2) photoperiods. Six rams were assigned to each group in late February and maintained in a controlled environment throughout the study. Scrotal circumference (testis size) decreased (10%) throughout the experiment in rams exposed to increasing photoperiods but increased (15%) in rams exposed to de-

Table 4.—Conception losses in natural bred and out-of-season mated ewes

	Breeding season (control)			Out-of-season mated[1]		
Time of mating	48 hr	12 days	Term	48 hr	12 days	Term
Number of ewes	10.0	10.0	10	10.0	10.0	10
Number of corpora lutea		26	32		52	39
Number of embryos[2]	21 (10)	30 (10)	22 (10)	32 (6)	20 (8)	19 (9)
Fertilization rate, percent[3]	80.5	93.8		89.5	66.7	
Number accessory sperm/ovum	79.1			5.5		

[1]Anestrous ewes (May) treated with flurogestone acetate pessary for 9 days plus 20 mg progesterone and 500 IU PMSG at removal.
[2]Number of ewes with either fertilized ova, blastocysts, or lambs, respectively, are listed in parentheses. Recovery rate for ova was 92.3 percent.
[3]Percentage of fertilized ova or blastocysts to corpora lutea for ewes with at least one embryo.

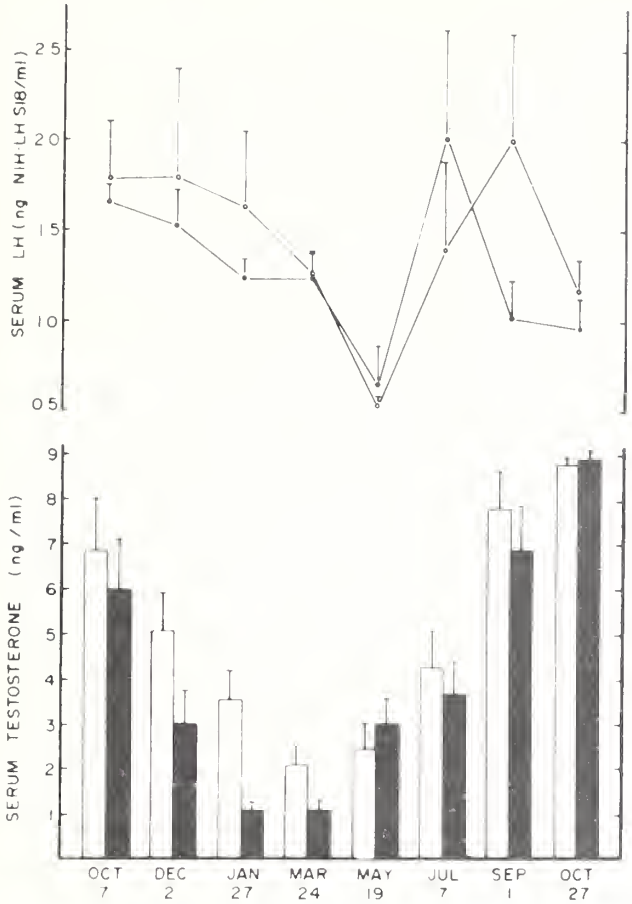

Figure 2—Serum LH and testosterone concentrations for eight evaluation periods from October 1974 through October 1975. Means ± SEM are given for Finn (open bars and circles) and Suffolk (closed bars and circles) rams.

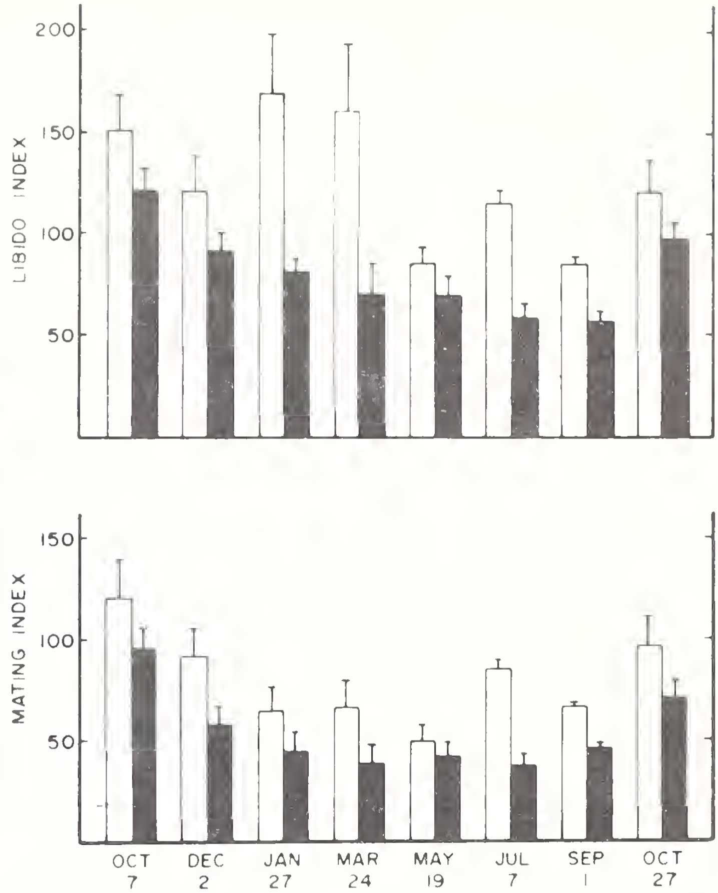

Figure 3—Libido and mating index scores for eight evaluation periods from October 1974 through October 1975. Means ± SEM are given for Finn (open bars) and Suffolk (closed bars) rams. Libido index was a measure of total sexual activity; mating index involved only completed matings.

creasing photoperiods. At the end of the study, group 1 rams that were exposed to short (8 hr light:16 hr dark) photoperiods had 45% heavier testes and were producing nearly twice as many sperm as were group 2 rams (16 hr light:8 hr dark). Although the differences in sperm production rates could be due to changes in several endocrine systems, group 1 rams were characterized by low concentrations of serum prolactin and elevated concentrations of serum testosterone, luteinizing hormone, and follicle stimulating hormone. Based on these findings, it is suggested that photoperiod-induced testicular growth in rams can be attributed to increased gonadotropin activity; and, by artificially reducing photoperiods, reproductive function can be enhanced in rams previously exposed to long photoperiods.

Experiment I evaluated the effect of photoperiod on fertility of rams. Five rams were exposed to artificial photoperiods of 8 hr light and 16 hr darkness for 10 weeks (short-day rams), and five rams were exposed to natural daylengths of spring (control) after which the rams were penned individually with 30 anestrous ewes treated with progestogen-PMSG to induce matings. Exposure of rams to short daylengths during the nonbreeding season (spring) initiated a new sexual cycle characterized by testicular growth, increased mating activity, and improved semen quality (Table 5).

Short-day rams mated 89% of the ewes compared to 67% mated by control rams (Table 6). Expressed as a percentage of the total ewes exposed per ram, 32% lambed from control matings; whereas, 67% lambed from mating to rams on short-days. Rams on short-days sired 2.5 times more lambs than control rams. Re-

Table 5.—Semen quality of rams exposed to natural or artificially shortened daylengths[1]

Treatment[2]	Time[3] (wks)	Semen quality: Progressive motility (pct)	Live sperm (pct)	Normal acrosome (pct)	Normal sperm[4] (pct)
Control rams	0	57 ± 7	57 ± 5	77 ± 5	87 ± 3
(natural photoperiod)	9	37 ± 12	63 ± 6	[5]36 ± 9	92 ± 2
Short-day rams	0	52 ± 11	63 ± 5	81 ± 4	86 ± 9
(8:16 photoperiod)	9	53 ± 5	69 ± 3	63 ± 8	90 ± 4

[1]Means ± SEM for 5 animals.
[2]Control rams were maintained out-of-doors under natural lighting conditions of spring whereas short-day rams were maintained in a closed building under controlled lighting (8 hr light and 16 hr darkness).
[3]Semen samples were collected and evaluated at the beginning of the study (time 0) and 9 weeks later just before breeding (time 9).
[4]Normal sperm, morphologically, excluding acrosome status.
[5]$P < .01$. Significantly different from initial value (time 0).

Table 6.—Lambing data for ewes mated to rams that were exposed to natural or artificially shortened daylengths[1]

Treatment[2]	Estrous activity (pct)	Mating activity (pct)	Lambing rate (pct)	Number lambs born per ewe lambing	Actual number lambs born
Control rams (natural photoperiod)	95.4 ± 2.3	66.7 ± 18.1	32.0 ± 0.05	1.72 ± 0.14	81
Short-day rams (8:16 photoperiod)	98.0 ± 1.3	89.3 ± 2.9	[3]67.2 ± 0.05	1.95 ± 0.12	202

[1]Means ± SEM for 5 animals. Values for lambing rate and number of lambs born per ewe lambing were derived from Least Squares Analyses.
[2]Control rams were maintained out-of-doors under natural lighting conditions of spring whereas short-day rams were maintained in a closed building under controlled lighting (8 hr light and 16 hr darkness for 91 days). Each ram was exposed to 30 progestogen-PMSG synchronized ewes. Data were collected and analyzed from two estrous cycles (21 day breeding period).
[3]P < .01. Significantly different from control rams.

sults of this experiment indicate that the ram contributes significantly to the fertility of out-of-season matings and that lamb production can be increased substantially by manipulation of photoperiod.

In experiment J, eight 1/2 Suffolk, 1/4 Finn rams were injected twice daily with 50 mg of gonadotropin releasing hormone (GnRH) for 3 months. Seven rams of similar breeding served as controls. After 2 months of treatment, each ram was placed with 23 or 24 ewes in which estrus was induced with progestogen-PMSG. GnRH had no effect on percentage of ewes lambing or lambs born/ewe. GnRH increased daily sperm production and the percentage of live sperm with progressive motility.

In experiment K, the effect of number of ewes per ram on conception rate was evaluated in ewes that were synchronized with progestogen-PMSG. Each of 15 Targhee rams was mated with 8, 12, 16, or 20 Targhee ewes. The number of ewes per ram had no influence on the percentage of ewes mated or conception rate at synchronized estrus. Percentage of ewes lambing and litter size were not affected by the number of ewes per ram.

Conculsion

Table 7 summarizes the results of our studies on the use of progestogen and PMSG to induce estrous behavior in ewes during the nonbreeding season. Conception rates of 60-65% were consistently achieved. In those instances where the conception rate was 30%, it was likely due to reduced fertility of the rams. The results of these studies clearly indicate that production of lambs can be increased by using progestogen and PMSG during the nonbreeding season.

Table 7.—Summary of lambing rates in ewes treated with progestogen and PMSG

Experiment Number		Breeding season	Number of ewes	Ewes lambing, percent		Breed of ram	Type of mating	Litter size	
				Control	Treated			Control	Treated
Ewe Studies:	A	May	240	16	63	Finn	Multiple-sire	1.46	1.62
	A	October	449	84	86	Finn	Multiple-sire	1.64	1.50
	B	June-July	799	2	26	Finn or Purebred	Multiple-sire	1.00	1.46
	C	April-May	165	5	63	Finn	Multiple-sire	1.40	1.86
	E	May	10	—	90	Finn-Cross	Hand	—	2.11
	F	June	280	7	61	Finn or Suffolk	Single-sire	2.00	2.20
	F	August	280	30	62	Finn or Suffolk	Single-sire	1.56	1.90
Ram Studies:	I	May	293	[1]32	67	Suffolk	Single-sire	1.72	1.95
	J	June-July	338	[1]62	60	1/2 Suffolk, 1/4 Finn	Single-sire	2.09	2.02
	K	September-October	204	—	96	Targhee	Single-sire	—	1.65

[1]All ewes were treated with progestogen-PMSG; treated rams were placed in short photoperiods in experiment I or received GnRH in experiment J.

NUTRITION

NUTRITIONAL INFLUENCES DURING PREGNANCY ON FETAL GROWTH AND DEVELOPMENT

Ronald L. Prior[1] and Ronald K. Christenson

Summary

Studies explaining the importance of maternal nutrition to optimal fetal development in sheep have been conducted recently. These efforts were aimed at increasing lamb vigor and viability at birth and during subsequent postnatal growth. Increasing digestible energy and crude protein intake for ewe lambs and yearling ewes during late gestation increased ewe average daily gain. However, level of energy intake fed ewe lambs and yearling ewes during late gestation did not significantly influence lamb birth weight or number and weight of lambs at weaning per ewe lambing. Lamb vigor increased for yearling ewes as energy level increased.

Providing adequate nutrients to the ewe during gestation is essential for fetal development and survival and for maximal lifetime production of the ewe. Studies measuring blood flow to and uptake of nutrients by the uterus and its contents have been completed. Utero-ovarian vein blood flow in ewes with twin fetuses at 105 days of gestation was 958 ± 164 ml/min and was 406 ml/min greater in ewes with triplets. Total glucose and amino acid uptake tended to increase with stage of gestation and tended to be greater at 105 days of gestation in ewes with triplets than in ewes with twins. Uterine blood flow and nutrient uptake appear to be closely related to amount of uterine, placental, and/or fetal tissue.

During pregnancy and lactation, gluconeogenesis and glucose metabolism takes on increased significance in the ruminant. Glucose appears to be a primary energy source for the fetus, and estimates show that approximately 40% of the glucose produced in maternal tissues is utilized by the fetus. The remaining glucose requirement of the fetus is coming from alternate sources (fatty acids and amino acids). Regulation of uptake of energy by the gravid uterus for use by the placenta and fetus is a function of blood glucose concentrations and uterine blood flow.

Introduction

Research has shown that Finnish Landrace (Finn) breeding in crossbred ewes increases reproductive performance. Greater fecundity by Finn-crosses has been attributed to earlier age at puberty and greater number of lambs born per ewe lambing. In studies at MARC, 88% of Finn-cross ewe lambs exposed to fertile rams at 7 months of age lambed and 1.5 lambs were born per ewe lambing. In general, ewe lambs reaching puberty at 7 months of age have a higher lifetime production and Finn-cross ewes most likely have greater lifetime nutritional requirements, especially since the ewes have multiple fetuses.

The primary objectives of these studies were to evaluate reproductive performance in Finn-cross ewe lambs and yearling ewes fed different dietary crude protein and digestible energy levels during late gestation, and to evaluate nitrogen (N) metabolism in both ewe lambs and yearling ewes during late gestation.

The effects of maternal dietary energy level on fetal energy reserves and the extent to which maternal dietary energy level and lamb energy reserves at birth affect early neonatal survival were also evaluated. In addition, in more basic studies, uterine blood flow, and nutrient uptake by the gravid uterus were studied in ewes with single, twin, or triplet lambs during late gestation.

Results

The effect of level of dietary energy and protein intake on reproductive performance was studied in 110 Finn-cross ewe lambs and in 404 Finn-cross yearling ewes during late gestation (Tables 1 and 2). Increasing digestible energy and crude protein intake for ewe lambs and yearling ewes during late gestation increased ewe average daily gain. However, level of energy intake fed ewe lambs and yearling ewes during late gestation did not significantly influence lamb birth weight or number and weight of lambs at weaning per ewe lambing. Percentage of lambs with strong vigor at birth was increased for yearling ewes as energy level was increased; and at 72 hr after birth, approximately 5 to 10% more lambs were alive for the yearling ewes with the high energy intake during late gestation. Protein intakes of 213 g/day during late gestation increased average lamb birth weight for yearling ewes to a greater extent than did protein intakes of 145 g/day. Lamb survival at weaning was greater for lambs from yearling ewes fed the high protein intake during late gestation.

N metabolism was studied in 26 ewe lambs and 23 yearling ewes. Endogenous fecal (N) loss for ewe lambs and yearling ewes was estimated to be .59 and .62 g/100 g dry matter intake, respectively. Endogenous urinary (N) loss was higher for yearling ewes at 134 days of gestation (278 mg N/kg body weight$^{.75}$/day) than for ewe lambs at 121 days of gestation (165 mg N/kg body weight$^{.75}$/day). About 60% of the increase in absorbed N required to maintain N balance observed in the yearling ewes, when compared with that of ewe lambs, is accounted for by the increased endogenous urinary N loss observed in the older ewes.

The effect of three levels of dietary energy on maternal glucose metabolism, fetal liver and heart glycogen, nucleic acids, and protein concentrations and early neonatal survival was studied in 227, 2- and 3-year-old Finnish Landrace crossbred (½) ewes. Increasing the level of dietary energy intake during late gestation increased average lamb birth weight, ewe plasma glucose and insulin, and decreased plasma free fatty acids (Table 3). Rates of glucose appearance were lower in ewes fed the low dietary energy level than in ewes fed the medium or the high energy level. Plasma glucose and glucose appearance rates tended to increase during an intravenous infusion of propionate (1 mmole/min) in ewes fed the low energy level but not in ewes fed the medium or the high energy level. Ewe plasma glucose increased approximately threefold within 30 min after parturition. Lambs born to ewes fed the low energy level had a lower concentration of liver nucleic acids. Level of dietary energy during late gestation did not significantly alter early neonatal survival of lambs.

Providing adequate nutrients to the ewe during gestation is essential for fetal development and survival and for maximal lifetime production of the ewe. As the potential number of embryos increases as a result of greater ovulation rate created by either the introduction of Finnsheep or by exogenous hormones, studies of fetal nutrition, development, and survival are needed. Only limited information is available on uterine and fetal utilization of nutrients and on uterine blood flow of ewes with single or twin lambs.

Twenty-three unanesthetized ewes with single, twin, or triplet lambs and with indwelling femoral artery and utero-ovarian vein catheters were studied at

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Table 1.—Effects of pre-lambing dietary energy intake on ewe weight gain, number and weight of lambs, and lamb vigor and survival (exp. 1)

Item		Dietary energy intake Low	Medium	High
No. of ewes lambing		117	126	117
Ewe weight[1]	lbs	128.0 ±2.2	125.4 ±2.2	124.1 ±2.2
Daily dry matter intake	lbs	2.44	3.04	3.63
Daily digestible energy intake	Mcal	3.42	4.31	5.21
Late gestation avg daily gain	lbs	[2].71± .037	[3].89± .038	[3].91± .037
Ewe pre-lambing weight	lbs	153.3 ±2.6	155.5 ±2.6	156.6 ±2.6
No. lambs born alive/ewe lambing		1.9 ± .07	1.9 ± .07	1.9 ± .07
Avg. live lamb birth weight ewe lambing[4]	lbs	8.8 ± .22	8.8 ± .22	8.6 ± .22
No. lambs weaned/ewe lambing		1.6 ± .08	1.4 ± .09	1.5 ± .08
Avg. lamb weaning weight/ewe lambing[5]	lbs	22.7 ± .88	22.7 ± .88	22.4 ± .88
No. of lambs		229	248	239
Lamb vigor at birth	percent			
Dead		9.6 ±2.4	4.7 ±2.5	5.2 ±2.7
Weak		[6]21.7 ±3.0	[6]15.2 ±3.2	[7]6.9 ±3.4
Strong		[6]68.7 ±3.5	[7]80.2 ±3.7	[8]87.8 ±4.1
No. of lambs alive at birth		216	237	225
Live lamb birth weight	lbs	8.8 ± .18	9.0 ± .18	9.0 ± .20
Lamb survival at 72 hr	percent	[6,7]93.4 ±2.5	[7]88.9 ±2.6	[6]98.2 ±2.8
Lamb survival at weaning	percent	82.9 ±4.5	75.9 ±4.7	71.9 ±5.1

[1]Initial treatment ewe weight at approximately 100 days of gestation.
[2,3]Means ± SE without a common superscript differ ($P<.01$)
[4]Lamb birth weight adjusted to twin birth basis
[5]Lamb weaning weight adjusted to twin birth and twin rearing basis
[6,7,8]Means ± SE without a common superscript differ ($P<.05$)

105 or 121 days of gestation. Glucose and amino acid uptake by the gravid uterus was determined from arterial-venous (A-V) differences and utero-ovarian blood flow measurements.

Utero-ovarian vein blood flow in ewes with twin fetuses at 105 days of gestation was 958 ± 164 ml/min and was approximately 406 ml/min greater in ewes with triplets at the same stage of gestation (Table 4). Utero-ovarian vein blood flow increased 400 ml/min as stage of gestation increased from 105 to 121 days of gestation for ewes with twins. Total glucose and amino acid uptake tended to increase with stage of gestation and tended to be greater at 105 days of gestation in ewes with triplets than in ewes with twins. Uterine blood flow and nutrient uptake appear to be closely related to amount of uterine, placental and/or fetal tissue.

Table 2.—Effects of pre-lambing dietary protein intake on ewe reproductive performance and on lamb birth weight, survival and growth to weaning (exp. 1)

Item		Dietary protein intake Low	Medium	High
No. of ewes lambing		113	116	131
Ewe weight[1]	lbs	126.7 ±2.2	123.0 ±2.2	127.8 ±2.2
Daily dry matter intake	lbs	3.00	3.01	3.12
Daily crude protein intake	lbs	.32	.37	.47
Late gestation avg daily gain	lbs	[2].57± .04	[3].93± .04	[3]1.02± .04
Ewe pre-lambing weight	lbs	[2]149.8 ±2.64	[2,3]154.4 ±2.64	[3]161.5 ±2.64
No. lambs born alive/ewe lambing		1.8 ± .07	2.0 ± .07	1.9 ± .07
Avg. live lamb birth weight/ewe lambing[4]	lbs	8.36± .22	8.58± .22	9.02± .22
No. lambs weaned/ewe lambing		1.5 ± .08	1.5 ± .08	1.6 ± .08
Avg. lamb weaning weight/ewe lambing[5]	lbs	21.3 ± .88	23.3 ± .88	23.1 ± .88
No. of lambs		234	234	248
Lamb vigor at birth	percent			
Dead		7.6 ±2.4	6.6 ±2.7	5.4 ±2.5
Weak		14.5 ±3.0	13.4 ±3.4	15.8 ±3.1
Strong		77.9 ±3.6	80.0 ±4.1	78.8 ±3.7
No. of lambs alive at birth		218	221	239
Live lamb birth weight	lbs	[6]8.6 ± .18	[6,7]9.0 ± .20	[7]9.5 ± .18
Lamb survival at 72 hr	percent	93.0 ±2.6	90.0 ±2.9	97.5 ±2.6
Lamb survival at weaning	percent	[6,7]76.9 ±4.6	[6]68.1 ±5.2	[7]85.6 ±4.6
No. of lambs at weaning[8]		166	171	190
Avg lamb weaning weight[8]	lbs	[6]26.6 ± .66	[7]28.8 ± .66	[7]28.6 ± .66
Avg daily gain	lbs	.41± .01	.45± .02	.44± .01

[1]Initial treatment ewe weight at approximately 100 days of gestation.
[2,3]Means ± SE without a common superscript differ ($P<.01$)
[4]Lamb birth weight adjusted to twin birth basis.
[5]Lamb weaning weight adjusted to twin birth and twin rearing basis.
[6,7]Means ± SE without a common superscript differ ($P<.05$).
[8]Average lamb age at weaning was 42 days.

Table 3.—Effect of dietary energy level on ewe plasma glucose, insulin and free fatty acids, weight gains and number and weight of lambs born to Finn-cross ewes (exp.1)

Item		Dietary energy level Low	Medium	High	SE
Nutrient intake[1]					
Total feed	lb/ewe/day	[6]1.71	[7]2.90	[8]3.75	44.10
Dry matter	lb/ewe/day	1.50	2.54	3.29	
Digestible energy	Mcal/ewe/day	2.6	4.5	5.8	
Crude protein	lb/ewe/day	.40	.47	.42	
Ca	g/ewe/day	8.5	8.7	8.2	
P	g/ewe/day	5.0	5.0	4.9	
Ewe weight					
Initial weight[2]	lbs	130.7	130.5	130.9	.50
Gain[3]	lbs	[6]1.06	[7]8.54	[8]17.29	.64
Lambing data[4]					
No. ewes lambing		11	12	11	
No. lambs born alive		2.17	2.27	2.0	.21
Avg lamb birth weight	lbs	[6]7.77	[7]8.87	[8]10.93	.26
Total lamb birth weight	lbs	16.59	19.49	20.17	.67
Ewe plasma glucose	mg/100ml				
Day 102 of gestation		[6]43.0	[7]50.4	[8]59.1	1.6
Day 122 of gestation		[6]37.9	[6]44.8	[7]61.4	3.2
Average lambing[5]		163.9	155.3	112.7	18.2
Ewe plasma insulin	ng/ml				
Day 102 of gestation		[6].59	[7]1.20	[7]1.44	.12
Day 122 of gestation		[6].74	[6].93	[7]2.52	.17
After lambing[5]		1.67	5.80	4.68	2.49
Ewe plasma free fatty acids	μmoles/ml				
Day 102 of gestation		[7]1.06	[6].64	[6].61	.08
Day 122 of gestation		1.51	1.31	1.16	.13
After lambing[5]		2.09	1.93	2.00	.22

[1]Average intake (on as fed basis) from January 15 through day of lambing.
[2]Ewes were started on their dietary treatments on January 15 (approximately day 81 of gestation).
[3]Period 1, day 81 through 109 of gestation.
[4]Expressed as per ewe lambing.
[5]Samples obtained within 30 min after parturition before lambs suckled.
[6,7,8]Means without a common superscript differ ($P<.01$).

Ruminant animals must derive most of their energy from acetic and propionic acids, ketone bodies, and deaminated residues of amino acids. Quantitatively, glucose is considerably less important in the metabolism of ruminants than in non-ruminants. The ruminant animal absorbs little or no glucose from the gastro-intestinal tract and therefore must synthesize nearly all of its required glucose. During pregnancy and lactation, glucose metabolism takes on increased significance in the ruminant. Glucose appears to be a primary energy source for the fetus. About 40% of the CO_2 in the pregnant uterus and its contents comes from blood glucose. The metabolism of glucose can account for about 50% of the oxygen uptake by the fetus.

With a continuous infusion of insulin, uterine glucose uptake in pregnant ewes decreased from a control rate of 21.0 ± 5.9 to 5.3 ± 3.6 mg/kg fetus/min after insulin infusion. Thus, uptake of energy by the gravid uterus for use by the placenta and fetus is a function of blood glucose concentrations. In pregnant ewes with one, two, or three fetuses at 109 days of gestation, glucose uptake by the uterus and its contents accounted for 42.6% of total glucose turnover. Uterine glucose uptake tended to increase with an increasing number of fetuses. Continuous intravenous infusion of glucose into pregnant ewes did not markedly alter blood flow to the uterus or amino acid uptake by the gravid uterus.

Table 4.—Uterine blood flow during late gestation in ewes with different number of fetuses (exp. 1)[1]

Item		Number of fetuses Single	Twin	Twin	Triplet
Stage of gestation	days	123	105	121	105
Blood flow[2]	ml/min				
Right UOV		538 ± 57 (2)	483 ± 84 (7)	479 ± 89 (6)	625 ±113 (7)
Left UOV		469 ± 65 (3)	541 ± 83 (7)	694 ±136 (4)	569 ±105 (6)
Total utero-ovarian vein blood flow[3]					
ml/min		1054 ±132 (2)	958 ±164 (6)	1358 ±248 (4)	1364 ±216 (5)
ml/lb of fetus/min		677.6±226.6 (2)	807.4±206.8 (5)	701.8± 85.8 (2)	730.4±132 (4)
Predicted total uterine arterial blood flow[4]					
ml/min		1396	1257	1832	1840
ml/lb of fetus/min[5]		844.8	928.4	752.4	928.4

[1]Data presented as means ± SE. Number of ewes in parentheses.
[2]UOV = utero-ovarian vein.
[3]Means ± SE were calculated for ewes with both right and left utero-ovarian blood flow data.
[4]Equation used was ($y = 81.3 + .697x$; where y = UOV blood flow by PAH method and x = arterial blood flow by microsphere method was used for calculation.
[5]Total fetal weight (Table 1) was used for calculation.

NUTRITION

FACTORS AFFECTING FEED UTILIZATION BY LAMBS

Calvin L. Ferrell[1]

Summary

Digestion-metabolism trials with Rambouillet, Dorset, and Finnish-Landrace (Finn) ram lambs showed no breed differences in digestibility of dry matter (DM), nitrogen (N) and energy. Other ram lambs fed showed that as the proportion of concentrate increased the digestibilities of DM, protein, and energy increased. The source of forage had a large influence on digestibility, alfalfa haylage being less than corn silage.

Other studies have shown that rams have a higher energy requirement for maintenance than ewes. Metabolized energy (ME) requirements for maintenance decreased as the percentage of concentrate increased. As animals became heavier, efficiency of ME for maintenance decreased, and ME available for gain and energy gain decreased.

Introduction

Feed is without doubt the single most costly component of a livestock production enterprise. As a result, it is extremely important to optimize the utilization of feed resources in an animal production system. In order to optimize the utilization of feed resources, however, a better understanding of the effects of various alternative factors on feed utilization needs to be developed. The following report is an attempt to briefly describe several studies of the effects of breed, diet, sex, and stage of growth on growth rate, body composition, and feed utilization by lambs.

Procedures and Results

Effect of breed or diet on digestibility:

Rambouillet, Dorset, and Finnish-Landrace (Finn) ram lambs (eight from each breed) were used in a series of digestion-metabolism trials. One-half of the rams were fed an 80% concentrate diet (20.5% crude protein) *ad libitum*, and one-half of the rams were fed the same diet at about 70% *ad libitum*. Digestibility of DM, N, and energy declined about 3% as intake increased by a multiple of maintenance. No breed differences in digestibility of any component were observed (Table 1). At the same relative intake, Rambouillet, Dorset, and Finn rams retained 32.2, 26.1 and 28.9% of the digested protein, respectively, with no breed differences in yield of metabolizable energy per unit diet DM observed.

Table 1.—Effect of breed on digestibility

Breed	Digestibility percent[1] Dry matter	Protein	Energy
Rambouillet	79.1±0.4	82.7±0.4	78.9±0.4
Dorset	78.3± .4	81.8± .5	78.3± .4
Finnish Landrace	79.4± .4	83.1± .5	79.4± .4

[1]Digestibilities were adjusted to constant levels of intake.

In a second study, 66 lb ram lambs were fed either a low, medium, or high concentrate diet (5 lambs/diet). These diets contained approximately 11, 49, or 86% concentrate with alfalfa making up the balance of each diet. The lambs were fed about 2.64 lb/day. Results, presented in Table 2, demonstrated a large effect of proportion of concentrate in the diet on digestibilities of DM, protein, and energy. Digestibilities of each of these components increased as the proportion of concentrate in the diet increased.

Table 2.—Effect of level of concentrate on digestibility[1]

Concentrate: roughage	Digestibility, percent Dry matter	Protein	Energy
11 : 89	63.0±1.4	68.8±2.1	60.6±1.7
49 : 51	67.1±1.8	68.9±1.6	65.3±1.6
86 : 14	75.4± .8	77.9± .9	75.5±1.1

[1]Digestibilities were determined using 66 lb ram lambs fed 2.6 lb of the original diet daily.

An additional study was designed to evaluate the effect of forage source as well as proportion concentrate in the diet on diet digestibility and lamb performance. Diets used in this study were (1) 80% corn silage, (2) 47% corn silage, (3) 14% corn silage, (4) 60% alfalfa haylage, (5) 36% alfalfa haylage, and (6) 11% alfalfa haylage. The balance of each diet consisted of corn, soybean meal, minerals, and vitamins.

DM intake, DM digestibility, and average daily gains of lambs fed each of these diets have been presented in Table 3. As was observed in the previous study, digestibility increased when proportion concentrate in the diet increased. When forage was a major component of the diet, the source of forage had a large influence on digestibility. The diets that contained alfalfa haylage were consistently less digestible than those containing corn silage, however, intake was consistently higher when lambs were fed the alfalfa haylage diets. As a result of the higher levels of intake, rates of gain by lambs fed the alfalfa diets was greater than those by lambs fed the corn silage diets.

These studies demonstrate that proportion concentrate in the diet, forage source and level of intake have major influences on digestibility. These results further indicate that lambs of different breeds have similar ability to digest feed.

Effect of sex, diet, and stage of growth on growth rate, feed efficiency, and body composition:

Lambs used in this study were ½ Suffolk, ¼ Finn, and ¼ Rambouillet, Dorset, or Targhee and initially weighed 37 lb. A factorial arrangement was used in which ram (56) and ewe (59) lambs were fed three diets differing in percentage concentrate and slaughtered at four weights. The lambs were individually fed in pens on a raised, expanded metal floor in an enclosed building. On all three diets, each lamb was fed approximately the same amount of feed daily as lambs of the same sex fed the high concentrate diet. One-fourth of the lambs within each sex-dietary treatment subgroup were slaugh-

Table 3.—Effect of forage source and level on feed intake, digestibility, and rate of gain

Roughage source	Percentage in diet	Dry matter intake, lb/d	Dry matter digestibility, percent	Average daily gain, lb/d
Corn silage	80	2.84	67.1	0.35
	47	2.95	74.8	.44
	14	2.95	78.8	.62
Alfalfa haylage	60	3.67	62.9	.42
	36	3.28	70.1	.51
	11	3.01	75.7	.66
Standard error		.16	3.2	.04

[1]Calvin L. Ferrell is a nutritionist at MARC.

Table 4.—Effects of sex, diet, and slaughter group within diet upon weight and gain of lambs[1]

Main effect		Number of animals	Days on feed	Final weight, lb	Daily live weight, gain lb/day
Sex:					
Ram	—	56	122	115.5	0.55
Ewe	—	59	122	98.8	.44
Diet:					
Low concentrate		38	144	106.7	.40
Slaughter group	1	10	71	67.8	.44
	2	8	155	94.4	.37
	3	9	211	125.2	.42
	4	11	281	139.5	.37
Medium concentrate		38	119	107.1	.51
Slaughter group	1	10	64	73.5	.57
	2	9	106	94.4	.55
	3	9	169	116.6	.46
	4	10	253	144.3	.42
High concentrate		39	105	107.4	.55
Slaughter group	1	10	56	70.4	.59
	2	10	99	91.7	.55
	3	10	155	119.7	.53
	4	9	211	147.6	.55
Standard deviation		...	...	3.1	.03

[1]All animals were adjusted to an initial weight of 37.6 lb.

tered when treatment mean live-animal weights of ram lambs were about 37, 70, 92, 119, or 145 lbs. Gross chemical composition (water, fat, protein, and ash) of each lamb was determined at slaughter.

Rams gained more rapidly (.55 *vs* .44 lb/day) and were heavier at slaughter (115.5 *vs* 98.8 lb) than ewe lambs (Table 4). Lambs gained .40, .51, and .55 lb/day and required 144, 119, and 105 days to reach slaughter weight on the low, medium, and high concentrate diets, respectively. Rate of gain decreased as lambs became heavier on the medium-concentrate diet and tended to decrease on the low-concentrate diet but remained essentially constant on the high-concentrate diet.

Final empty body weight of rams was greater than that of ewes (Table 5). Rams contained more water and protein but less fat than ewes and tended to contain less energy. Even though mean final weights were similar among lambs fed different diets, as a result of constant slaughter-weight endpoints, final empty body weight differed among dietary treatment groups. These results were indicative of decreased gut fill as percentage concentrate in the diet increased. Empty body water, fat, and energy differed as a result of dietary treatment, but body protein was similar among dietary treatments. Final empty body weight and weight of all components increased with slaughter weight or time on feed.

Various estimates of efficiency are presented in Table 6. Rams required less feed DM per pound of empty body gain than ewes (5.8 *vs* 6.5). Daily ME requirement for maintenance of rams was greater than for ewes (62 *vs* 60.3 kcal/$W^{.75}$). Daily ME available for gain was similar (96.9*vs* 97.4 kcal/$W^{.75}$), but rams gained less energy than ewes (29.9 *vs* 34.9 kcal/$W^{.75}$, daily). These results indicate that rams had both a higher requirement for maintenance and a lower efficiency of energy utilization for gain than ewes.

Feed-to-empty-body-gain ratio differed as a result of dietary treatment (Table 6). These ratios were 7.7, 6.0, and 4.8 for the low, medium, and high concentrate diets, respectively. The ME requirements for maintenance decreased in response to increased percentage concentrate. The efficiency of utilization of ME above maintenance for gain by lambs fed the low, medium, and high concentrate diets were .30, .33, and .37, respectively. These results indicated the efficiencies of ME utilization for both maintenance and gain increased with increased percentage concentrate in the diet. Feed-to-gain ratios and daily ME required for maintenance generally increased, and ME available for gain and energy gain generally decreased as slaughter weight increased, indicating a decreased efficiency as lambs became heavier.

Table 5.—Effects of sex, diet, and slaughter group within diet upon final empty body weight and weight of gross chemical components of lambs

Main effect		Weight	Water	Fat	Protein	Energy
		Pound				*Mcal*
Sex:						
Ram		86.2	49.5	17.6	14.4	120
Ewe		74.1	37.8	20.9	11.4	126
Diet:						
Low concentrate		77.0	42.7	17.8	12.8	117
Slaughter group	1	49.5	29.5	9.0	8.4	63
	2	73.0	39.8	17.6	12.1	113
	3	86.2	48.4	19.6	14.1	130
	4	99.0	52.8	24.9	16.5	161
Medium concentrate		80.1	43.5	19.1	12.9	122
Slaughter group	1	53.2	31.9	8.8	8.8	63
	2	66.9	37.2	14.9	11.3	97
	3	90.0	49.1	21.3	14.2	136
	4	110.2	55.9	31.7	17.3	192
High concentrate		83.6	45.1	20.7	13.1	130
Slaughter group	1	53.2	32.8	9.0	9.0	64
	2	72.2	40.7	15.6	11.3	101
	3	95.3	49.7	26.2	14.3	158
	4	113.5	57.2	32.3	17.6	196
Standard deviation		2.5	1.4	1.5	.46	15

Table 6.—Effects of sex, diet, and slaughter group within diet upon gross feed efficiency, energy requirements for maintenance, energy available for gain, and energy gain by lambs

Main effect		Dry matter empty body gain, lb/lb	HPM[1]	MEAC[2]	Daily energy gain kcal/$W^{3/4}$
Sex:					
Ram	—	5.8	62.0	96.9	29.9
Ewe	—	6.5	60.3	97.4	34.9
Diet:					
Low concentrate		7.7	63.1	89.1	26.6
Slaughter group	1	6.2	60.3	107.4	33.2
	2	8.1	62.0	91.3	29.3
	3	7.4	64.2	81.4	23.8
	4	9.0	65.3	75.8	21.6
Medium concentrate		6.0	60.3	100.2	32.7
Slaughter group	1	4.5	60.3	109.6	35.4
	2	6.0	58.7	132.3	37.1
	3	6.3	61.4	85.2	30.4
	4	7.1	62.0	73.1	27.1
High concentrate		4.8	59.2	103.0	37.6
Slaughter group	1	4.1	59.2	123.4	38.7
	2	4.7	59.2	112.4	39.3
	3	4.9	58.7	90.2	38.7
	4	5.3	59.8	85.2	33.8
Standard deviation		.97	4	42	11

[1]Heat production at maintenance in kcal/Wkg, daily; equal to ME required for maintenance where W is in kg
[2]ME available for gain in kcal/Wkg, daily where W is in kg.

NUTRITION

EARLY WEANING OF ARTIFICIALLY REARED LAMBS TO DRY DIETS

Wilson G. Pond[1], Calvin L. Ferrell, Thomas G. Jenkins, Larry D. Young, and Mike H. Wallace

Summary

Drenching with fresh rumen fluid does not aid in weaning young lambs to a dry diet. Early weaning (at 10 days of age) to a dry diet may be complicated by inadequate water intake, which can cause rumen compaction. However, lambs weaned early can be compared to that of lambs fed liquid diets to 28 days in growth and feed efficiency.

Introduction

Four preliminary experiments have been completed with a total of approximately 100 artificially reared lambs raised in the MARC nursery on a conventional liquid feeding schedule or on a modified schedule in which weaning to a dry diet was accomplished at 10 days of age. The conventional feeding schedule for artificially reared lambs at MARC is to bottle feed a commercial liquid diet to 4 weeks of age, first *ad libitum,* and then, beginning at 14 days, limited quantities (8 oz/ feeding) twice per day to 28 days. A standard dry lamb starter diet is offered *ad libitum* beginning at about 2 weeks. This procedure is expensive, both in feed cost and in labor requirement and often is associated with sanitation problems (cleaning equipment and offering fresh liquid feed). A dry diet if consumed in adequate amounts at an early age (10 days) would reduce feed costs and labor requirements dramatically.

Procedure and Results

The first experiment established that drenching twice per day with 10cc of freshly collected rumen fluid or 10cc of a water suspension of dry diet was not necessary to allow weaning to a dry diet at 10 days of age. It had been suggested by others that rumen function of the young lamb might be stimulated by this procedure.

The second and third experiments suggest that growth and feed utilization of lambs weaned at 10 days of age may be comparable to that of lambs fed liquid diets to 28 days of age. However, in each experiment, approximately 20-25% of lambs weaned to the dry diet at 10 days of age died within about a week after weaning with the reticulorumen distended and impacted with feed; there was no evidence of ingesta having passed into the abomasum and lower gastro-intestinal tract. One possible explanation for this phenomenon would be inadequate water intake by early weaned lambs immediately after weaning, resulting in excessively dry rumen contents and subsequent impaction. Reduction in the incidence of rumen impaction would enhance the attractiveness of weaning to a dry diet at 10 days of age in terms both of feed cost and of labor requirements, since performance of survivors is comparable to that of conventionally reared nursery lambs.

A fourth experiment has been completed to determine whether supplemental water given via a nursing nipple during the first week after weaning to dry diet will reduce the incidence of rumen impaction and improve survival rate. The results suggest that other unknown causes are responsible for rumen impaction. It appears that the practice of weaning to a high energy dry diet as early as 10 days of age may prove to be a practical management scheme in the future if death losses can be reduced to levels comparable with those of lambs fed a liquid diet.

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[1]Wilson G. Pond is a research leader (nutrition) at MARC.

NUTRITION

GLUCOSE AND LACTATE ABSORPTION AND METABOLIC INTERRELATIONSHIPS IN LAMBS SWITCHED FROM LOW TO HIGH CONCENTRATE DIETS

Gerald B. Huntington[1], Ronald L. Prior[2], and Robert A. Britton

Summary

Lambs switched gradually to a high concentrate diet did not alter net portal absorption of D-lactate. The change did increase L-lactate and glucose absorption and turnover.

Abrupt switching to an all-concentrate diet did not cause acidosis and showed a blood acid-base status peak 12-16 hr after the switch.

Introduction

Little information has been reported on carbohydrate absorption and rates in feedlot ruminants consuming high concentrate diets.

Appreciable amounts of starch in high concentrate diets may escape rumen fermentation and are susceptible to enzymatic degradation in the small intestine, but the extent of this type of degradation or its effect on glucose absorption in ruminants is not clear.

Sources of lactate entering the bloodstream include: (1) the diet; (2) rumen (and perhaps lower digestive tract) fermentation; and (3) endogenous production. Absorption of dietary lactate may be significant when silages or other fermented feeds are consumed. Increased absorption of both D- and L-lactate is suggested by elevated blood plasma concentration concurrent with increased consumption of concentrates. More information on absorption rates of both L- and D-lactate would be of value in elucidating energy metabolism and describing acidosis in feedlot ruminants.

It has been assumed that absorbed D-lactate is metabolized slowly or not at all but recent work suggests more than one avenue of dissipation of blood D-lactate may exist when plasma concentrations are maintained at high levels. L-lactate may be an important glucose precursor or may play a significant role in fatty acid synthesis.

[1]Gerald B. Huntington is a nutritionist, USDA, Beltsville, Md.

[2]Ronald L. Prior is a research chemist at MARC.

Design

Objectives of these experiments were (1) to measure portal glucose and lactate absorption in lambs before and after an increase in concentrate intake and (2) to study post-absorptive interconversion and turnover of these metabolites in lambs.

Two experiments were conducted to measure portal absorption rates of glucose, L-lactate, and D-lactate and turnover rates of glucose and L-lactate in lambs switched either gradually (Experiment 1) or abruptly (Experiment 2) from hay to a high concentrate diet. Blood samples were collected every 20 min over a 3-hr period from portal vein and femoral artery cannulas. After about 4 weeks of gradual adaptation to a pelleted, 85% concentrate diet, the infusions and collection procedures were repeated. In Experiment 2, four lambs were abruptly switched from a pelleted hay to an all concentrate diet. Portal and arterial blood samples were collected before and every 20 min after the diet switch.

Results

Data from the first experiment are summarized in Table 1. Net portal absorption of D-lactate was not altered significantly by dietary concentrate level; the experiment mean was 1.58 mmoles/hr. Net portal absorption of L-lactate ($P<.10$) and glucose ($P<.05$) and turnover of L-lactate and glucose increased ($P<.05$) in response to increased dietary concentrate intake. L-lactate absorption as a percent of turnover and conversion of L-lactate to glucose were not affected by the diet switch. Percent of glucose derived from L-lactate decreased from 10.01 to 5.51.

Lambs in the second experiment switched abruptly to an all-concentrate diet did not become acutely acidotic. However, the initial insult to blood acid-base status peaked 12-16 hr after the diet switch, concurrent with maximum arterio-venous differences of L-lactate and glucose. Arterio-venous differences in D-lactate did not appear to be affected by the diet switch.

Table 1.—Influence of diet on parameters of glucose and lactate metabolism in sheep (Exp. 1)

Live body wt.	lbs	[1]61.51	[1]66.58	1.50
Daily dry matter intake[2]	lbs	2.32	2.33	.17
Portal blood flow	1/hr	78.69	104.44	9.75
Plasma D-lactate	mM:			
Portal		.24	.24	.01
Arterial		0.22	0.21	0.04
Plasma L-lactate	mM:			
Portal		.95	.79	.08
Arterial		[3].87	[3].68	.06
Plasma glucose	mg/dl:			
Portal		76.4	83.	3.
Arterial		77.5	80.9	3.3
Net portal absorption	mMoles/hr:			
D-lactate		1.30	1.85	.77
L-lactate		[3]4.10	[3]6.53	.84
Glucose		[4]-2.71	[4]8.09	1.11
Portal glucose utilization	mMoles/hr	1.86	5.20	3.21
Portal glucose absorption	mMoles/hr	[4]-.85	[4]13.29	2.45
L-lactate turnover	mMoles/hr	[1]33.90	[1]48.80	2.65
L-lactate absorption	percent of turnover	12.26	13.09	2.67
Glucose turnover	mMoles/hr	[4]28.50	[4]53.20	2.
L-lactate to glucose	mMoles/hr	5.57	5.74	1.10
Glucose from L-lactate	percent	[1]10.09	[1]5.51	1.84

[1]Diet means are significantly different ($P<.05$)
[2]Average intake 5 days before infusion.
[3]Diet means are significantly different ($P<.10$).
[4]Diet means are significantly different ($P<.01$).

NUTRITION

POTENTIAL FOR ANAEROBICALLY FERMENTED CATTLE RESIDUES AS A FEED INGREDIENT FOR SHEEP

Ronald L. Prior[1] and Andrew G. Hashimoto

Summary

Dried centrifuged cake (DCC) when substituted in the diet for alfalfa hay will decrease dry matter, nitrogen (N), and metabolizable energy intakes. However, fecal N is increased, which suggests that some of the N in alfalfa is more digestible than in DCC. The digestibility of ash in the total diet is decreased almost by 50%, which may prove to be one of the major problems in utilizing biomass.

Sheep fed the fermentor effluent (FE) show a decrease in apparent N digestibility. Bentonite added to diets (both effluent and control) significantly increases N retention. Bentonite is a clay that absorbs protein and enables it to pass through the rumen without being degradated.

Introduction

In large cattle feedlots, feedlot waste is produced in huge quantities and must be disposed of by some means. According to recent estimates, about 2 billion metric tons of animal wastes containing about 2.2 million metric tons of N are produced annually in the United States. Probably less than 50% of this waste is recoverable. Moreover, unless managed properly, animal wastes are a potential pollutant in our environment. Recycling of animal waste as livestock feed merits investigation as a potentially useful source of feed nutrients and as a means of lowering the disposable waste load.

A process has been developed involving the principles of anaerobic fermentation to convert cattle waste into a fuel gas (methane-rich) and a protein-rich solid residue. The detailed engineering and operational parameters of the pilot-scale thermophilic, anaerobic fermentor used in experiments at MARC have been published elsewhere. Briefly, the material used in these nutritional studies has been obtained as follows: fresh manure is gathered daily from steers housed in a partially roofed structure with concrete-floored pens. Antibiotics and other feed additives have not been fed to these steers. The manure is transported to the pilot plant by a small front-end loader and dumped into the slurry tank, where water is added and the slurry is mixed for approximately 2 hr. Samples are then taken for total solids (TS) and volatile solids (VS) determination. Based on the TS and VS concentrations, a given amount of slurry is then pumped into a weigh tank, and water is added to dilute the slurry to a specified VS concentration. The slurry in the weigh tank (referred to as FE) is mixed while the slurry is pumped into a heat exchanger loop and into the fermentor, which has a working volume of 5.1 m^3. Before adding fresh slurry into the fermentor, a specified volume of fermented effluent, corresponding to the desired retention time, is removed (retention time is the total fermentor slurry volume divided by the volume of fresh slurry added each day). The FE is either mixed directly with other feed ingredients for livestock feeding trials or centrifuged (wet centrifuge cake, WCC) or centrifuged and dried at 70°C (referred to as DCC). Since livestock waste has been successfully fed to ruminants, it would be expected that the biomass resulting from the anaerobic fermentation process should likewise be useful as a feed ingredient.

Utilization of Nutrients by Sheep

1. Refeeding of DCC.—The composition of the diets used in one experiment each with sheep is presented in Table 1. In the diets for the sheep experiment, DCC was substituted for alfalfa hay. The substitution was made since alfalfa hay has a similar content of fiber components, amino acids, and gross energy as the DCC.

The results of feeding 0, 5, 10, or 20% of the diet DM as DCC to sheep are presented in Table 1. DM intake tended to decrease somewhat (6-14%) when DCC was included in the diet fed to sheep. Because DM intake was reduced somewhat in sheep, N and metabolizeable energy intake were also decreased slightly with rations containing DCC.

Fecal N as a percentage of N intake increased in sheep from 41.5 to 48.6% for the control diet compared to the diet containing 20% biomass (Table 2). Regression analysis indicated that fecal N increased 0.3 to 0.4% for each increment of 1% increase in DCC in the diet. This suggests that a component of the N in DCC is less digestible than the N in alfalfa hay fed to sheep. Most likely this undigestible N is associated with the highly lignified components of the DCC. However, the most marked changes occurred in the digestibility of the ash component of the diet, which decreased from about 51-60% in the control ration to about 28% with the 20% DCC ration. By partitioning the grams of ash digested by the sheep (Y) between the grams of ash provided by the biomass (X_1) and the grams of ash from the remainder of the diet (X_2) using multiple regression techniques, the digestibility of ash in the biomass was predicted to be 11.3% compared to 59.4% in the remainder of the ration. Silica accounts for about 63% of the total ash and represents a fraction that is relatively indigestible.

Table 1.—Composition[1] of diets using various levels of dried centrifuge cake in sheep

Ingredient	International reference number	Dried centrifuge cake level 0	5	10	20
Brome, smooth, hay, S-C	1-00-947	10.1	10.1	10.1	10.1
Corn, yellow, grain, grnd	4-02-992	64.7	64.7	64.7	64.7
Alfalfa, hay, S-C grnd	1-00-111	20.7	15.5	10.4	0
Dried fermentor biomass		0	5.2	10.3	20.7
Salt		.28	.28	.28	.28
Molasses		4.21	4.21	4.21	4.21
		100.00	100.00	100.00	100.00
Nutrient Composition, dry matter basis:[2]					
Dry matter, percent		89.2	89.4	89.0	89.5
Organic matter, percent		94.2	93.7	93.1	92.1
Crude protein, percent		12.1	12.1	12.1	11.8
Gross energy, Mcal/kg		4.40	4.38	4.29	4.26
Ash, percent		5.8	6.3	6.9	7.9

[1]Expressed on dry matter basis.
[2]Values based on laboratory determinations.

[1]Ronald L. Prior is a research chemist at MARC.

Table 2.—Influence of level of dried centrifuge cake in the diet for sheep on diet intake and nitrogen (N) metabolism and apparent digestibilities of diet components[1]

Item		Level of dried centrifuge cake 0	5	10	20
Dry matter intake	lb/day	2.26 ±0.09	2.13 ±0.07	1.95 ±0.13	2.08 ±0.12
N intake	lb/day	.043 ± .002	.041 ± .001	.037 ± .002	.039 ± .002
Urine N	percent of intake	32.4 ±2.0	31.4 ±1.8	33.7 ±6.3	30.4 ±2.4
Fecal N	percent of intake	41.5 ±2.7	44.9 ±2.0	43.2 ±1.1	48.6 ±1.9
N retained	lb/lb DDM	.0069	.0063	.0062	.0058
Apparent digestibility, percent:					
Dry matter		72.5 ±1.7	71.6 ±1.0	72.2 ±0.9	68.0 ±2.1
Organic matter		73.5 ±1.7	73.5 ±0.9	75.2 ±0.8	71.5 ±2.1
Nitrogen		58.5 ±2.7	55.1 ±2.0	63.9 ±7.8	51.4 ±1.9
Ash		^{2}59.5 ±2.0	^{3}46.3 ±2.3	^{3}40.0 ±1.0	^{2}28.4 ±1.6
Energy		70.2 ±1.8	70.0 ±1.2	71.4 ±1.0	68.1 ±2.1

[1]Data presented as means ± SEM of 3 to 5 ram lambs per treatment
[2,3]Means without a common superscript differ ($P < 0.05$)

The relatively ineffective utilization of the ash component of the DCC may present one of the major problems in effectively utilizing the biomass as a feedstuff particularly when more than one cycle of the refeeding process occurs.

2. Refeeding FE as fresh or ensiled ration.—Because of the low capture efficiencies (especially for N) and the high capital and operating costs associated with centrifugation, other methods to recover the fermentation nutrients were investigated. Studies were undertaken to mix the FE directly with cracked corn and hay and to feed this diet to livestock. Advantages of this method are that 100% of the FE is used and much of the ammonia in the effluent is retained in the ration. A possible disadvantage is that a diet moisture content of between 60 to 65% is necessary for the FE to provide all of the diet supplemental N. This high moisture level may reduce "bunk life" and cause the feed to freeze during the winter.

The effect of feeding FE with or without bentonite in the diet on N metabolism in sheep was also evaluated. The diets that were fed are presented in Table 3. Bentonite was mixed with the appropriate dry diet prior to adding either water or FE. The sheep were adapted to the diet containing FE by initially adding only 25% of the full amount of FE for the first 2 days. The amount of FE was increased by 25% every 2 days so that by day 7, the sheep were receiving 100% of the specified amount of FE. Acceptance of the diets containing FE by the sheep was depressed when the complete mixed diet was first offered. However, the adaptation seemed to be facilitated by gradually introducing FE into the diet.

Results of the experiment with sheep are shown in Table 4. Approximately 1.76 lb of ration DM was consumed by animals on both treatments. Average daily gains for 21 days prior to the metabolism study were .44 and .45 lb/day for the control and

Table 3.—Composition[1] of diets fed to sheep in exp. 2

Ingredient		International reference number	Control	Control + bentonite	Effluent biomass	Effluent biomass + bentonite
Wheat, straw		1-05-175	10.00	9.78	10.00	9.77
Corn, yellow, grain, grnd		4-02-992	82.08	80.28	82.61	80.66
Soybean, seeds, solv-extd, grnd		5-04-605	7.05	6.89	---	---
Limestone, grnd, mn 33 percent Ca		6-02-632	.87	.86	.94	.92
Vitamins A, D and E			+	+	+	+
Solids from fermentor effluent			---	---	6.45	6.61
Bentonite			---	2.19	---	2.04
			100.00	100.00	100.00	100.00
Nutrient composition, dry matter basis[2]:						
Dry matter, after adding						
H_2O or effluent	percent		38.0	37.7	37.7	37.8
Organic matter	percent		91.7	93.7	92.7	91.9
Crude protein	percent		11.6	12.9	11.5	13.0
Gross energy	Mcal/kg		4.42	4.47	4.49	4.44
Ash	percent		5.4	3.7	4.3	5.1
Ca	percent		.47	.49	.49	.36
P	percent		.37	.28	.33	.32
Mg	percent		.17	.18	.17	.21

[1]Expressed on dry-matter basis.
[2]Values based on laboratory determinations.

Table 4.—Influence of fermentor effluent and bentonite on diet intake and nutrient utilization in sheep

Item		Control + H_2O	Control + H_2O + bentonite	Fermentor effluent (FE)	Fermentor effluent + bentonite	SEM[1]
No. animals		5	5	5	5	
DM intake	lb/day	^{2}1.71	^{3}1.82	^{3}1.85	^{3}1.87	11.8
N intake	lb/day	^{2}.31	^{4}.38	^{3}.33	^{4}.39	.3
ME intake	Mcal/day	2.68	2.87	2.69	2.77	.05
N metabolism:						
Fecal N	percent of intake	^{2}27.5	^{2}28.1	^{4}41.2	^{3}35.6	1.2
Urine N	percent of intake	^{3}46.0	^{2}27.6	^{3}38.6	^{2}31.4	3.2
Retained N, lb/lb digested DM		^{2}.006	^{3}.011	^{2}.005	^{3}.009	.9
Apparent digestibility:	percent					
Dry matter		^{4}81.4	^{3}79.0	^{2}75.4	^{2}74.6	.8
Organic matter		^{3}82.8	^{3}82.2	^{2}77.1	^{2}77.7	.7
Ash		^{5}66.2	^{2} 1.0	^{4}39.8	^{3}23.2	2.0
Gross energy		^{3}81.3	^{3}81.0	^{2}74.4	^{2}75.3	.8
N		^{4}72.6	^{4}71.9	^{2}58.8	^{3}64.4	1.2

[1]Pooled standard error mean.
[2,3,4,5]Means without a common superscript differ ($P < 0.05$).

FE treatment, respectively, showing no statistically significant difference between the control and FE treatments.

Fecal N was increased in the sheep fed FE compared to sheep fed the control ration (Table 4). This was also reflected in the decrease in apparent N digestibility in sheep fed the FE compared to control animals. A statistically significant reduction in ash digestibility was observed in sheep fed the FE.

The addition of bentonite to the control diet or the diet containing FE significantly increased N retention. Bentonite, when added to the control or FE diets, decreased the percentage of urine N. These effects of bentonite, when added to a wetted diet, of increasing N utilization are consistent with other results published.

Other than ash digestibility, the largest reduction in digestibility of any ration component measured occurred in N digestibility. Two probable reasons for this lower N digestibility are (1) about 50% of the N in the FE was ammonia, which is less efficiently utilized than protein N; and (2) a portion of the organic N appears to be undigestible (indicated by the increase in fecal N of the sheep receiving the ration containing FE compared to the control ration). The lower ash and N digestibility of rations containing FE may be of concern when this material is refed for long periods. Long-term feeding trials are necessary to evaluate this potential problem.

MEATS

PRODUCTION OF HEAVY WEIGHT MARKET LAMBS

John D. Crouse[1], Calvin L. Ferrell, and Virden L. Harrison

Summary

Sixty-eight ram and 70 ewe lambs were fed diets containing three metabolizable energy densities (.99, 1.09, and 1.27 Mcal/lb) and serially slaughtered after ram lambs attained live-animal weights of 37.4, 70.4, 92.4, 118.8, and 145.2 lb.

Quality grades differed between sexes; however, these differences were not reflected in taste panel palatability scores except for aroma. Heated fat aroma scores from ram lamb carcasses were inferior to those of ewes.

Reduced percentages of carcass protein and ash were associated with the higher energy density diets. Percentages of kidney and pelvic fat increased with dietary energy; however, no differences in fat thickness or *longissimus* muscle area were observed. Carcasses of lambs receiving the high energy diets were judged to be physiologically older than those receiving the medium or low energy diets at constant hot carcass weights. The taste panel judged meat from the low energy diet to be inferior in tenderness to meat from the high energy diet.

Introduction

Production of heavy market lambs with high cutability could result in improved efficiency of production and processing of lamb meat. A previous study by Harrison and Crouse indicated that net returns to producers can be improved by feeding ram lambs a high energy diet to live weights up to 44 lb heavier than normal industry slaughter weights. Increased product availability and reduced retail prices of lamb are also likely consequences of the development of efficient methods of producing heavy market lambs. However, heavier carcasses will be acceptable to retailers only if they are lean because leanness of cut ranks high on consumer response lists. In addition, for lamb meat to be desirable to consumers, it must also have acceptable palatability devoid of mutton flavor and aroma.

Ram lambs have superior growth rate, feed efficiency, and cutability when compared to ewe or wether lambs. Meat from ram lambs has similar palatability characteristics to meat from wether or ewe lambs at live-animal weights up to 121.0 lb. However, palatability characteristics of lean meat of very heavy rams have been found inferior, in some instances, to the palatability characteristics of wethers.

The objectives of this experiment were to study the effects of management variables, weight, sex, and diet on lamb meat palatability and composition so that management systems could be developed that economically produce a highly acceptable heavy weight market lamb.

Materials and Methods

Sixty-eight ram and 70 ewe lambs were fed diets containing one of three digestible energy levels of 5.94, 6.40, or 7.30 Mcal/lb. Lambs were ½ Suffolk, ¼ Finn and ¼ Rambouillet, Dorset, or Targhee. Lambs were born from April 28 to June 7, were weaned August 1, and weighed about 37.4 lb at the initiation of the trial.

Lambs were individually fed and live weights obtained at 28-day intervals. In an effort to ensure energy intake differences among the three diets, all lambs within sex were fed the same daily amount of feed based on quantities of feed consumed by lambs fed the high energy diet. Weights of refused feed were recorded daily and actual intake per lamb was kept. Lambs were slaughtered in one of four groups when lambs reached live-animal weights of 70.4, 92.4, 118.8, or 145.2 lb. Routine cooler data, chemical composition, and lean meat palatability were obtained on lamb carcasses.

Results and Discussion

Growth and Carcass Composition Traits. Least-squares means for production and carcass traits are presented in Table 1. Cumulative feed intake differences between sexes, among diets, and among slaughter groups were highly significant. It is interesting to note that cumulative feed intake increased more toward the end of the feeding trial for ram than ewe lambs and the increase was the greatest for the high energy diet. The rams gained faster than the ewes all during the test, but the difference was greatest at heavier weights.

Sex Effects. Ewe lambs had larger percentages of carcass fat than ram lambs (24.58 vs 19.86) when slaughtered at constant ages even though carcass weights for ewe lambs were 5.28 lb lighter. USDA yield grades were greater for ewe lambs than ram lambs; however, the .8 difference in trimmed primal cuts was of no significant consequence. Sex differences in percentages of carcass fat were due to fat thickness and quantities of kidney and pelvic fat. Reductions in protein, moisture, and ash in ewe when compared to ram lambs were also observed.

Diet Effects. Dietary energy treatments affected carcass composition only to a minor degree. Carcass protein decreased slightly with increases in energy density of the diet. Percentages of trimmed primals were not affected by dietary density.

Diet did not affect either the 12th rib fat thickness or leg conformation scores. However, when animals were fed the higher energy diets the percentages of kidney and pelvic fat were increased and the yield grades were greatly increased.

Carcass Quality—Sex Effects. Means for carcass quality traits are given in Table 2. Ewe lamb carcasses had higher conformation (10.31 *vs* 9.71) scores, higher quality grades (9.92 *vs* 9.47), and greater amounts of fat in the *longissimus* muscle (loin eye at 12th rib) than did ram carcasses. Ewe lambs appeared to be more youthful, and the lean meat color of ewes appeared to be lighter in color than lean meat of ram lambs.

"Buckiness" (primarily thickness in neck and shoulders) increased at a much faster rate in ram carcasses than ewe carcasses, which would be expected. However, regression analysis of "buckiness" on hot carcass weight (not given) for the two sexes was not significantly different. This would indicate that as weight increases "buckiness" increases within the two sexes to the same degree. Slopes of the regressions of "buckiness" on time on feed were found to be different between sexes. The shape of the regressions indicate that increased "buckiness" scores associated with ram carcasses are dependent on age rather than weight.

Diet Effects. Indicators of maturity were affected by energy intake over time on feed or at a constant hot carcass weight. When means for dietary energy treatments were computed on a time on feed constant basis, means for overall maturity for low, medium, and high energy diets were 2.08, 1.74, and 2.48, respectively. These rankings indicate that lambs on high energy diets are physiologically more mature than lambs on low or medium energy diets at a constant point in time on feed. Apparently, rate of maturing increased with increased rates of gain associated with higher energy diets.

[1]John D. Crouse is a research food technologist (meats) at MARC.

Table 1.—Least-squares means and standard errors for carcass compositional traits

Subclass	Number	Time on feed	Cumulative feed	Slaughter weight	Carcass weight	Adj. fat thickness	Fat thickness	Kidney and pelvic fat	Longissimus muscle area	Yield grade	Trimmed primals	Carcass protein	Carcass moisture	Carcass fat	Carcass ash	SE coefficient
		days	(lb)	(lb)	(lb)	(in)	(in)	(pct)	in^2		(pct)	(pct)	(pct)	(pct)	(pct)	
Ram	68	122	402.12	94.53	45.94	0.125	0.112	1.46	2.16	2.73	64.5	17.17	56.69	19.86	4.87	0.122
Low energy diet																
Slaughter group:	23	144	494.72	95.50	45.94	.121	.113	1.20	2.21	2.58	64.4	17.49	57.26	19.58	5.04	.222
1	4	1	2.64	37.30	16.38	.035	.014	.29								
2	5	71	214.95	65.45	32.80	.083	.080	1.03	1.01	1.93	63.5	18.51	67.01	7.87	5.21	.501
3	4	155	491.63	97.82	46.30	.131	.150	1.37	1.79	2.40	66.0	17.31	57.87	18.89	4.34	.458
4	5	211	722.23	127.85	60.76	.172	.159	1.30	2.72	2.79	66.7	17.50	54.56	22.31	4.79	.503
5	5	281	1043.45	149.05	73.46	.214	.161	2.02	2.83	2.71	64.2	17.10	55.12	22.34	5.31	.459
Medium energy diet									2.69	3.08	61.3	17.01	51.74	26.50	5.53	.485
Slaughter group:	22	119	401.90	94.97	45.94	.110	.094	1.32	2.16	2.56	64.7	17.18	56.39	19.68	5.11	.215
1	4	1	−.66	37.10	16.38	.000	.000	.31								
2	5	64	171.08	68.78	32.80	.085	.079	.90	1.20	1.98	65.0	17.96	65.14	8.64	4.82	.500
3	4	106	436.78	95.68	46.30	.127	.084	1.41	1.77	2.48	65.3	17.07	57.76	18.75	4.49	.447
4	4	169	542.78	122.16	60.76	.150	.156	1.65	2.08	2.50	65.6	17.51	53.90	22.75	5.80	.515
5	5	253	859.36	143.63	73.46	.186	.151	2.33	2.92	2.67	65.4	16.84	54.75	20.67	4.93	.501
High energy diet									2.85	3.08	62.5	16.51	50.41	27.62	5.52	.451
Slaughter group:	23	104	309.31	93.12	45.94	.144	.127	1.86	2.10	3.05	64.3	16.86	56.43	20.31	4.46	.222
1	4	1	−1.10	37.15	16.38	.000	.000	.29								
2	5	56	149.91	63.14	32.80	.085	.087	1.14	1.17	1.96	65.3	18.15	66.74	8.48	4.66	.500
3	5	99	278.66	90.98	46.30	.153	.134	.18	1.78	2.58	66.3	17.26	58.68	17.12	4.46	.448
4	5	155	446.21	121.78	60.76	.191	.186	2.50	1.97	3.17	65.6	16.41	55.33	21.79	4.25	.449
5	4	211	672.85	145.17	73.46	.291	.243	3.48	2.86	3.40	63.3	16.09	52.30	26.01	4.24	.467
									2.70	4.16	61.2	16.38	48.07	28.22	4.67	.535
Ewe	70	122	357.81	81.77	40.72	.175	.165	2.29	1.93	3.54	63.7	16.07	53.08	24.58	4.50	.121
Low energy diet									1.93	3.38	64.9	16.31	52.80	25.00	4.69	.213
Slaughter group:	23	144	445.99	33.24	40.72	.166	.153	2.08								
1	4	1	−3.31	39.11	17.06	−.012	.000	.33	1.17	1.95	68.3	17.00	63.42	11.15	4.06	.501
2	5	71	191.14	63.71	30.64	.124	.142	1.03	1.55	2.71	67.4	16.95	55.53	22.24	4.56	.449
3	4	155	733.11	84.22	41.86	.216	.207	2.72	2.09	4.16	62.8	15.94	48.44	29.96	4.59	.502
4	4	211	611.61	107.85	52.29	.211	.182	2.72	2.39	3.79	64.4	15.58	50.01	29.29	4.38	.502
5	6	281	907.86	117.05	61.95	.157	.240	3.62	2.44	4.28	61.6	16.07	46.62	32.35	4.83	.422
Medium energy diet									1.95	3.64	62.7	16.09	52.66	24.52	4.62	.211
Slaughter group:	23	119	349.43	82.41	40.72	.192	.175	2.30								
1	4	1	.88	35.47	17.06	.001	.001	.33	.99	1.98	64.7	17.45	64.51	9.62	5.12	.500
2	5	64	170.20	63.07	30.64	.112	.106	1.80	1.76	2.76	66.0	16.54	56.59	17.85	4.16	.448
3	4	106	305.56	82.50	41.86	.179	.145	2.11	1.94	3.49	62.0	16.87	50.54	26.63	5.37	.502
4	5	169	508.83	103.43	52.29	.315	.244	3.38	2.61	4.76	62.0	14.64	47.14	32.97	4.09	.450
5	5	253	761.48	120.79	61.95	.351	.382	4.58	2.43	5.20	58.9	14.94	44.50	35.55	4.37	.453
High energy diet									1.91	3.58	63.5	15.80	53.78	24.24	4.20	.207
Slaughter group:	24	104	349.43	79.63	40.72	.167	.166	2.50								
1	4	1	2.87	36.49	17.06	.010	.008	.36	.91	2.04	66.0	17.83	65.37	10.19	4.60	.501
2	5	56	132.72	55.09	30.64	.113	.109	1.15	1.72	2.83	65.6	17.16	59.64	19.30	4.55	.449
3	5	99	273.37	80.86	41.86	.196	.185	2.47	1.97	3.89	64.7	15.04	51.71	25.71	4.02	.447
4	5	155	420.64	104.39	52.29	.266	.294	3.93	2.58	4.71	61.1	13.99	46.25	33.71	4.06	.453
5	5	211	561.74	115.01	61.95	.251	.235	4.58	2.38	4.53	60.2	14.97	45.93	32.27	3.77	.452
Diets:																
Low energy	46	144	470.47	89.35	43.32	.144	.133	1.64	2.07	2.98	64.6	16.90	55.03	22.29	4.86	.157
Medium energy	45	119	375.67	88.69	43.32	.151	.135	1.81	2.05	3.10	63.7	16.63	54.52	22.10	4.87	.151
High energy	47	105	293.88	86.38	43.32	.155	.148	2.18	2.00	3.32	63.9	16.33	55.10	22.27	4.33	.155
Sd. residual[1]			36.12	4.05		.046	.057	.61	.27	.43	2.7	.98	2.36	3.15	.54	

[1]Standard error of the subclass mean = SE coefficient X SD.

Table 2.—Least-squares means and standard errors for carcass qualitative traits

Subclass	Conformation score[1]	Buckiness score[2]	Overall maturity[3]	Bone maturity[3]	Lean maturity[3]	Lean color[4]	Fat color[5]	Quality grade[1]	LD fat(%)	LD moisture(%)	SE coefficient[6]
Ram	9.71	2.18	2.23	2.19	2.16	2.70	1.65	9.47	2.73	74.13	0.122
Low energy diet											
Slaughter group:	9.38	2.26	2.74	2.71	2.66	3.12	1.86	9.15	2.83	74.31	.222
1	2.73	1.04	1.03	1.04	1.05	1.01	.99	3.53	1.10	76.15	.501
2	10.62	1.10	1.09	1.09	1.12	1.02	.96	10.36	2.22	74.99	.458
3	10.80	1.65	2.70	2.68	2.93	3.47	3.01	10.02	2.28	73.98	.503
4	11.15	3.77	3.30	3.12	2.74	4.04	2.37	10.86	3.68	73.61	.458
5	11.60	3.74	5.59	5.63	5.46	6.09	1.96	10.99	4.25	72.82	.484
Medium energy diet											
Slaughter group:	9.87	2.18	1.82	1.77	1.73	2.39	1.56	9.59	2.44	74.02	.215
1	3.77	.99	.99	.99	.99	1.00	1.01	3.25	1.11	75.77	.500
2	10.78	.99	.99	.99	.99	1.00	1.00	10.38	1.44	75.43	.447
3	11.30	1.73	1.12	1.15	1.17	1.31	.97	11.17	3.03	73.64	.515
4	11.74	3.28	2.24	2.01	2.00	3.26	2.02	11.45	2.19	73.16	.502
5	11.77	3.91	3.74	3.72	3.51	5.38	2.82	11.69	4.41	72.12	.451
High energy diet											
Slaughter group:	9.88	2.11	2.13	2.07	2.09	2.59	1.54	9.67	2.92	74.04	.222
1	3.64	.98	1.00	.99	1.00	.99	.99	3.16	1.04	76.19	.500
2	9.64	.99	1.01	1.00	1.01	.99	1.39	9.68	2.61	73.67	.448
3	11.24	2.12	1.76	1.75	1.95	2.98	1.00	11.21	2.97	73.79	.449
4	12.23	2.77	3.06	2.84	3.01	3.55	2.04	12.07	4.31	73.28	.467
5	12.68	3.67	3.81	3.77	3.48	4.18	2.30	12.22	3.69	73.28	.535
Ewe	10.31	1.04	1.86	1.92	1.78	2.39	1.37	9.92	3.59	72.92	.121
Low energy diet											
Slaughter group:	10.32	1.05	2.29	2.33	2.27	2.89	1.51	9.76	3.73	73.15	.213
1	3.89	1.01	1.03	.96	.96	1.01	1.00	4.37	1.07	75.77	.501
2	11.39	.98	.98	1.05	1.05	.98	1.00	9.81	3.12	74.24	.449
3	11.71	1.07	1.01	1.98	2.24	1.60	1.98	11.00	4.54	72.19	.502
4	11.70	1.00	2.13	2.55	2.30	2.57	1.75	11.46	5.55	71.72	.502
5	12.92	.87	3.55	5.13	4.80	4.16	1.83	12.15	4.37	71.85	.422
Medium energy diet											
Slaughter group:	10.47	.99	1.54	1.55	1.42	2.21	1.21	10.13	3.71	72.37	.211
1	3.76	.94	1.01	1.01	1.01	1.00	1.00	3.77	1.47	74.39	.500
2	11.07	1.08	.98	.98	.97	1.20	1.01	10.02	2.03	74.37	.448
3	12.50	.95	1.02	1.04	1.03	1.27	1.01	11.74	3.10	71.97	.502
4	13.01	1.08	1.97	1.98	1.77	2.81	1.62	12.75	6.52	69.90	.449
5	12.03	1.20	2.73	2.71	2.03	4.77	1.41	12.37	5.44	71.22	.452
High energy diet											
Slaughter group:	10.12	1.11	1.74	1.89	1.65	2.07	1.40	9.86	3.34	73.23	.207
1	4.05	1.05	.97	1.03	1.04	.98	.99	3.83	1.21	75.81	.500
2	10.18	.93	1.03	.97	.97	1.22	.99	9.59	1.94	74.19	.449
3	11.55	1.00	2.00	1.01	1.01	3.48	.99	11.57	3.04	73.28	.447
4	12.32	.88	2.53	2.92	1.90	3.52	2.02	12.63	5.12	71.65	.452
5	12.50	1.67	4.93	3.52	3.32	5.22	2.00	11.67	5.39	71.01	.452
Diets:											
Low	9.85	1.66	2.52	2.52	2.47	3.01	1.68	9.45	3.28	73.73	.157
Medium	10.17	1.58	1.68	1.66	1.57	2.30	1.39	9.86	3.07	73.73	.151
High	10.00	1.61	1.93	1.98	1.87	2.33	1.47	9.76	3.13	73.20	.155
SD, residual[6]	1.00	.40	.47	.47	.57	.51	.30	1.03	1.20	1.42	

[1]Scored 10 = low choice, 11 = average choice, 12 = high choice, etc.
[2]Scored 1 = no evidence to 4 = typical mature ram.
[3]Scored. 1 = A minus, 2 = A typical, 3 = A plus, etc.
[4]Scored 1 = slightly dark pink to 9 = dark red.
[5]Scored 1 = white to 5 = dark yellow
[6]Standard error of subclass mean = SE coefficient X SD

Similar to carcass fat and moisture, *longissimus* muscle fat and moisture were not affected by dietary energy. Though quality grade was not appreciably affected by diet when both sexes were included, it is apparent that higher energy diets do increase quality grades in rams. An unexplainable decline in quality grades from the fourth to fifth slaughter group for ewes on the medium and high energy diets contributed to the lack of a significant relation between diet and grade level.

Palatability—Sex Effects. Taste panel observations were made on the low and high energy density diets for the third, fourth, and fifth slaughter groups. Means are given in Table 3.

With the exception of lower Warner-Bratzler (W-B) shear values for ram meat

Table 3.—Least-squares means and standard errors for palatability traits

Subclass	No.	Tenderness[1]	Juiciness[2]	Flavor[2]	Aroma[3]	Overall satisfaction[2]	W-B shear[4]	SE coefficient[5]
Ram	28	5.4	5.0	5.7	3.8	5.7	3.3	.19
Low energy diet	14	5.0	5.0	5.7	3.4	5.6	3.5	.29
Slaughter group:								
3	4	5.4	5.1	6.0	3.0	5.8	3.6	.50
4	5	5.6	5.3	5.9	3.4	6.0	3.0	.47
5	5	3.9	4.6	5.1	3.9	5.1	3.9	.50
High energy diet	14	5.8	5.1	5.6	4.2	5.7	3.1	.30
Slaughter group:								
3	5	5.1	4.5	5.3	3.9	5.3	3.9	.45
4	5	7.5	6.3	6.1	4.1	6.5	1.7	.48
5	4	4.7	4.5	5.5	4.5	5.3	3.7	.55
Ewe	29	5.9	4.9	5.8	4.4	5.8	4.3	.19
Low energy diet	14	5.2	4.5	5.6	4.2	5.5	4.4	.28
Slaughter group:								
3	4	6.5	4.5	5.8	4.3	5.9	3.9	.50
4	4	5.0	4.9	5.9	3.4	5.7	4.1	.50
5	6	4.0	4.1	5.2	4.8	4.9	5.1	.43
High energy diet	15	6.5	5.3	6.1	4.5	6.2	4.2	.26
Slaughter group:								
3	5	6.3	4.8	5.9	4.3	6.0	5.3	.45
4	5	7.3	5.7	6.3	4.4	6.6	2.9	.45
5	5	6.0	5.5	6.0	4.9	6.0	4.4	.45
Diets:								
Low energy	28	5.1	4.7	5.7	3.8	5.6	3.9	.21
High energy	29	6.2	5.2	5.8	4.3	5.9	3.7	.21
SD, residual[5]		1.4	.8	.5	1.0	.7	1.2	

[1]Scored: 1 = extremely tough to 9 = extremely tender.
[2]Scored: 1 = extremely dislike to 9 = extremely like.
[3]Scored: 1 = very strong aroma to 9 = no aroma.
[4]Kilograms of force required to shear a 1.27 cm core of cooked meat.
[5]Standard error of subclass mean = SE coefficient X SD.

than ewe meat, these data are in general agreement with those in previous studies. Previous studies of carcasses up to approximately 55.0 lb in weight have shown no consistent or meaningful differences among rams, wether, or ewes for juiciness and flavor; however, W-B shear values are generally greater for ram carcasses than for ewe or wether carcasses.

Palatability—Diet Effects. Meat from lambs fed low energy diets was evaluated by the taste panelists to be less tender than meat from lambs fed the high energy diets. W-B shear values were not in agreement with tenderness scores. Juiciness scores for meat from ewes fed the high energy diet tended to be superior to scores for meat from ewes fed the low energy diets. Rams fed the low energy diet tended to have higher aroma scores than rams fed high energy diets.

CUTABILITY OF HEAVY LAMBS FROM FINN AND DOMESTIC CROSSBRED EWES AND BY SUFFOLK, HAMPSHIRE, AND OXFORD SIRES

Gordon E. Dickerson,[1] John D. Crouse, and Larry W. Olson

Summary

Differences among breeds of sire or dam in yield of lean lamb percent of live weight were of minor importance.

Introduction

Previous comparisons of carcass merit and predicted yields of cuts for market lambs from Finn and domestic-crossbred ewes at the Center were based solely on carcass measurements. In 1974, through the cooperation of Wilson and Co. at Omaha, actual yields of the four "Cryovac-packed" major trimmed and the "rough" wholesale cuts also were obtained, in addition to the usual predicted yields based on carcass measurements for lambs carried to relatively heavy final weights.

Procedure

Trimmed cuts and cooler carcass data were obtained at two live weights of about 114 and 127 lb for 823 ewe and wether lambs by Suffolk (S), Hampshire (H), and Oxford (O) sires, produced by 3- and 4-year-old purebred ewes from seven domestic breeds (P), Rambouillet-cross (R_x), and Finn-cross (F_x) ewes. Distribution of numbers by breeding of sire and dam, slaughter weight, sex, and age of dam is shown in Table 1. Lambs of each sex were assigned randomly to the two slaughter weights. The lambs had been weaned at 5 to 7 weeks of age and reared in feedlots on a corn silage base, 12% C.P. ration.

Results

Slaughter groups differed in mean age (210 *vs* 254 days), in body wall thickness (.9 *vs* 1.0 in), in dressing % (50.6 *vs* 51.8), and in trimmed major cuts (41.7 *vs* 42.8 lbs) (Tables 2, 3, and 4). Wethers were 14 days younger than ewe lambs but dressed 1% less with slightly poorer quality and conformation grades, less back and kidney fat but only .4 lb less trimmed cuts.

Lambs from Finn-cross ewes averaged 14 days older than lambs from R_x and P ewes, possibly due to their higher frequency of twins, and had .8% more kidney fat and slightly poorer conformation but only 1.2 lb less predicted and 0.5 lb less actual trimmed cuts than lambs from R_x ewes at the same slaughter live weight.

Breed of maternal granddam had significant effects on market lamb performance (Tables 5, 6, and 7). Lambs from ½ Targhee, ½ Suffolk, or ½ Corriedale ewes were about 2 weeks younger than those from ½ Dorset ewes. Lambs from ½ Hampshire and ½ Dorset ewes were highest in dressing %, quality and conformation grades, and yield of trimmed cuts and shortest legged. Those from ½ Suffolk and ½ Rambouillet had least external fat and best yield grade but were lower in actual cut yields than lambs from ½ Hampshire or ½ Dorset ewes because of a lower dressing %.

Breed of sire ranking of market lambs (Tables 2, 3, and 4) was S<O<H for age at market weight but H>S, O for dressing % and kidney fat, H>O>S for quality and conformation grades, and O>H>S for external fat and fat trim. Suffolk sired lambs excelled in yield grade and in predicted yields of boned and trimmed cuts, but actual yields of trimmed cuts were nearly the same for all three breeds of sire, again due to minimal actual trimming of excess fat.

Table 1.—Structure of 1974 carcass data

Ewe breed		Sire of lambs			Slaughter weights		Sex		Age ewe	
Type	G-dam	Suffolk	Hampshire	Oxford	133.3 lb	126.5 lb	wether	ewe	3 yr	4 yr
P, R_x, F_x[1]	Suffolk	—	56	47	49	54	54	49	77	26
	Hampshire	52	—	42	48	46	42	52	79	15
	Dorset	39	39	55	71	62	61	72	61	72
	Rambouillet	35	39	33	52	55	55	52	60	47
	Targhee	44	46	51	72	69	66	75	85	56
	Corriedale	31	43	33	55	52	55	52	68	39
	Coarse Wool	39	48	51	61	77	73	65	72	66
P	All	78	92	96	129	137	121	145	125	141
R_x	All	50	61	81	95	97	100	92	144	48
F_x	All	112	118	135	184	181	185	180	233	132
Total	All	240	271	312	408	415	406	417	502	321

[1]P = Purebred, R_x = ½ Rambouillet and F_x = ½ Finn.

Table 2.—Constant live weight carcass merit for heavy terminal-cross lambs from Finn and Rambouillet-cross and purebred ewes of 7 dam breeds[1]—age, dressing percent, and carcass grading

Effect	Numbers	Slaughter age-days	Dressing percent	Carcass grades: Quality	Conformation	Leg	Marbling	Maturing
Sire:								
Suffolk	240	226	51.0	12.1	11.7	12.1	9.3	1.17
Hampshire	271	237	51.7	12.6	12.4	12.3	9.2	1.15
Oxford	312	232	50.9	12.6	12.4	12.0	9.1	1.11
Mat. G'-sire:								
Purebred	266	229	51.0	12.4	12.2	12.1	9.0	1.17
Ramb-x	192	227	51.4	12.5	12.3	12.3	9.3	1.15
Finn-x	365	242	51.5	12.3	12.0	11.9	9.4	1.08
Sex:								
Wether	406	225	50.8	12.3	12.0	11.9	9.0	1.22
Ewe	417	238	51.6	12.5	12.4	12.3	9.4	1.07
Slau. group:								
1 (114 lbs)	408	209	50.5	12.5	12.2	12.1	9.1	1.11
2 (127 lbs)	415	255	51.9	12.3	12.2	12.1	9.3	1.17

[1]1974 spring Phase II GPE lambs from 3- and 4-year-old ewes. Adjusted for regression on slaughter weight, by breed and age of dam, to final live weights of 114 and 127 lb.

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Table 3.—Constant live weight carcass merit for heavy terminal-cross lambs from Finn and Rambouillet-cross and purebred ewes of 7 dam breeds[1]—cooler measurements and predicted cutability

Effect	Length leg-in	12th rib thick. in Fat	Body wall	Color of Lean	Fat	Kidney fat (pct)	Yield grade	Predict. (pct) boned cuts
Sire:								
Suffolk	4.51	0.31	0.87	4.01	2.0	5.0	4.3	43.0
Hampshire	4.42	.37	.99	4.62	2.0	5.2	4.7	42.3
Oxford	4.46	.43	1.05	4.25	2.0	4.6	5.0	41.8
Mat. G'-sire:								
Purebred	4.43	.38	.96	4.01	2.0	4.7	4.6	42.4
Ramb-x	4.52	.35	.96	4.30	2.0	4.8	4.5	42.6
Finn-x	4.49	.37	1.01	4.84	2.0	5.6	4.9	42.0
Sex:								
Wether	4.52	.35	.92	4.12	2.0	4.5	4.4	42.8
Ewe	4.42	.40	1.02	4.46	2.0	5.4	4.9	41.9
Slau. group:								
1 (114 lbs)	4.45	.38	.92	4.19	2.0	4.8	4.7	42.3
2 (127 lbs)	4.49	.37	1.02	4.39	2.0	5.0	4.7	42.3

[1]1974 spring Phase II GPE lambs from 3- and 4-year-old ewes. Adjusted for regression on slaughter weight, by breed and age of dam, to final live weights of 114 and 127 lb

Table 4.—Constant live weight carcass merit for heavy terminal-cross lambs from Finn and Rambouillet-cross and purebred ewes of 7 dam breeds[1]—carcass yield (lb)

Effect	Kidney fat	Trim fat	Rough cuts	Trim cuts Should.	Rack	Loin	Leg	Total trim cuts Actual	Predict.
Sire:									
Suffolk	3.14	4.89	10.9	13.0	6.75	6.22	16.2	42.1	43.7
Hampshire	3.21	5.13	10.9	13.3	7.05	6.42	15.7	42.5	43.2
Oxford	2.80	5.29	10.8	12.9	7.03	6.41	15.6	42.0	42.4
Mat. G'-sire:									
Purebred	2.85	5.17	10.8	13.0	6.96	6.34	15.8	42.1	43.3
Ramb-x	2.95	4.94	11.0	13.1	6.90	6.38	16.2	42.6	43.6
Finn-x	3.54	5.13	10.9	13.2	6.98	6.35	15.6	42.1	42.4
Sex:									
Wether	2.77	4.97	11.0	13.1	6.84	6.25	15.8	42.0	43.5
Ewe	3.33	5.24	10.8	13.0	7.05	6.45	15.9	42.4	42.7
Slau. group:									
1 (114 lbs)	2.92	5.00	10.8	12.9	6.65	6.30	15.9	41.7	43.1
2 (127 lbs)	3.18	5.20	11.0	13.3	7.24	6.41	15.9	42.8	43.1

[1]1974 spring Phase II GPE lambs from 3- and 4-year-old ewes. Adjusted for regression on slaughter weight, by breed and age of dam, to final live weights of 114 and 127 lb.

Table 5.—Constant live weight carcass merit for heavy terminal-cross lambs from Finn and Rambouillet-cross and purebred ewes of 7 dam breeds[1]—age, dressing percent, and carcass grading

Effect	Numbers	Slaughter age-days	Dressing percent	Carcass grades Quality	Conf.	Leg	Marbl.	Matur.
Mat. G'-dam:								
Suffolk	103	228	51.1	12.3	12.1	12.4	9.2	1.19
Hampshire	94	232	51.7	12.8	12.9	12.7	9.1	1.10
Dorset	133	240	52.1	12.7	12.7	12.5	9.4	1.10
Rambouillet	107	232	51.0	12.3	11.9	12.0	9.0	1.15
Targhee	141	226	51.1	12.2	11.8	11.7	9.2	1.16
Corriedale	107	229	50.3	12.3	12.1	11.9	9.2	1.15
Coarse Wool	138	236	51.1	12.3	11.7	11.6	9.3	1.16

[1]1974 spring Phase II GPE lambs from 3- and 4-year-old ewes. Adjusted for regression on slaughter weight, by breed and age of dam, to final live weights of 114 and 127 lb.

Table 6.—Constant live weight carcass merit for heavy terminal-cross lambs from Finn and Rambouillet-cross and purebred ewes of 7 dam breeds[1]—cooler measurements and predicted cutability

Effect	Length leg-in	12th rib thick. in Fat	Body wall	Color of Lean	Fat	Kidney fat (pct)	Yield grade	Predict (pct) boned cuts
Mat. G'-dam:								
Suffolk	4.42	0.36	0.92	3.75	2.0	4.6	4.5	42.6
Hampshire	4.35	.40	.98	4.07	2.0	4.4	4.6	42.4
Dorset	4.34	.39	1.03	4.62	2.0	4.7	4.7	42.3
Rambouillet	4.60	.32	.92	4.45	2.0	4.9	4.4	42.9
Targhee	4.54	.35	.96	4.41	2.0	5.1	4.6	42.4
Corriedale	4.49	.40	.96	4.36	2.0	5.3	5.0	41.8
Coarse Wool	4.54	.38	1.00	4.38	2.0	5.4	4.9	42.0

[1]1974 spring Phase II GPE lambs from 3- and 4-year-old ewes. Adjusted for regression on slaughter weight, by breed and age of dam, to final live weights of 114 and 127 lb

Table 7.—Constant live weight carcass merit for heavy terminal-cross lambs from Finn and Rambouillet-cross and purebred ewes of 7 dam breeds[1]—carcass yields (lbs)

Effect	Kidney fat	Trim fat	Rough cuts	Trim cuts Should.	Rack	Loin	Leg	Total trim cuts Actual	Predicted
Mat. G'-dam:									
Suffolk	2.85	5.08	10.9	13.0	6.85	6.36	16.1	42.3	43.8
Hampshire	2.71	5.16	11.1	13.4	7.09	6.47	15.9	42.9	44.1
Dorset	2.96	5.09	10.9	13.5	7.19	6.65	16.0	43.4	43.7
Rambouillet	3.01	4.80	11.1	13.0	6.76	6.27	16.1	42.1	43.3
Targhee	3.18	5.25	10.7	13.0	6.84	6.29	15.9	42.0	42.8
Corriedale	3.21	5.21	10.6	12.6	6.88	6.20	15.4	41.1	42.0
Coarse Wool	3.41	5.13	10.9	12.9	7.01	6.22	15.6	41.8	42.1

[1]1974 spring Phase II GPE lambs from 3- and 4-year-old ewes. Adjusted for regression on slaughter weight, by breed and age of dam, to final live weights of 114 and 127 lb.

CARCASS COMPOSITION OF HEAVY LAMBS FROM FINN AND DOMESTIC CROSSBRED EWES AND BY SUFFOLK, HAMPSHIRE, AND OXFORD SIRES

Jimmy W. Wise,[1] Gordon E. Dickerson,[2] Roger W. Mandigo, and John D. Crouse

Summary

Chemical fat in soft carcass tissues was nearly 2% higher for lambs from Finn-cross than in those from Rambouillet-cross ewes and 2.2% higher for Hampshire-sired and 3.4% higher for Oxford-sired than for Suffolk-sired lambs. Domestic breed of maternal granddam also affected fat content of soft tissue appreciably. Thus, fat content of market lamb can be changed greatly by choice of breeds used in crossbred lamb production.

Introduction

Carcass information on 1971-1973 spring lambs from Finn-cross (F_x), Rambouillet-cross (R_x), and purebred (P) ewes sired by Suffolk (S), Hampshire (H), and Oxford (O) rams was based solely on cooler measurements and scores of the uncut carcass. To determine the composition of lambs from these breeding groups more precisely, a 5th rib carcass cross-section from each of 810 crossbred lambs produced in the spring of 1974 was recovered to measure separable fat and lean tissue, chemical analyses of all soft tissue, the *longissimus* muscle, and the tenderness of a cooked muscle sample (Wise, 1977).

Procedure

Ten Suffolk, 12 Hampshire, and 7 Oxford rams sired 400 ram and 410 ewe lambs produced by 3- and 4-year-old F_x, R_x, and P ewes from 7 domestic breeds of dam, as shown in Table 1. Lambs were born in February-March, 1974, under semi-intensive confinement, with access to a creep ration (50% ground shelled corn and 50% alfalfa) soon after birth. Ewes and lambs were placed on cool season pasture in early April. Male lambs were castrated at 5 to 10 days of age. Lambs were weaned at 10 ± 2 weeks and assigned randomly within breed of sire and dam groups to 110 and 125 lb minimum slaughter weight groups. After a 2-week adjustment period with *ad libitum* alfalfa hay, weaned lambs were fed a 13.5% C.P. silage, corn, and soybean meal growing finishing ration. Lambs were slaughtered when the mean of the slaughter group reached the assigned minimum weight. Actual mean weights were 114 and 125 lb for the two slaughter groups.

Carcass weights, measurement scores, and grades were obtained with cooperation of Wilson and Co., Omaha, after 24 hr in the cooler. Then a 1-inch thick cross-section cut from the anterior end of the 5-12 rib section of the carcass was vacuum packaged and stored at -29°C.

The left one-half of the 5th rib section was used for physical lean-fat separation and chemical analysis and the right one-half for cooling-tenderness measurement. Two ½-inch core samples of *longissimus* muscle were cooked and each sheared twice for mean Warner-Bratzler shear test of tenderness. Fat, protein, moisture, and ash were determined for all soft tissue and for *longissimus* muscle of each one-half carcass sample.

Results

Slaughter Weight and Sex Effects—The mean increase in slaughter weight from 114 to 125 lb required about 34 more days (to 254 *vs* 210 days of age) and increased carcass weight from 59 to 65 lb separable fat by 2.1% and chemical fat by 2.3% in soft tissue, with comparable decreases in separable and chemical lean tissue (Table 1). Although the increase for chemical fat in muscle was only 1.0%, the *proportional* increase of fat in muscle was even greater than in all soft tissue (i.e., 1.0/7.9 = .13 *vs* 2.3/44.7 = .05). Tenderness of cooked muscle did not change with the increase in slaughter weight. The actual change in fat content of soft tissue between slaughter weight groups corresponded closely with that predictable from the regressions on carcass weight among individual animals within sex, slaughter weight, and breeding group classes.

Breed of Sire Effects—Suffolk-sired lambs had less separable and chemical fat in soft tissue than Hampshire-sired (-2.2%) and especially Oxford-sired (-3.6 and -3.4%) lamb, but there were almost no breed of sire effects on composition of *longissimus* muscle (Table 2). Cooked muscle from Suffolk-sired lambs was a little more tender than that from Hampshire- or Oxford-sired lambs.

Breed of Dam Effects—Lambs from ½ Finn-crossbred (F_x) ewes had 1.6% more separable and 1.9% more chemical fat in soft tissue than those from ½ Rambouillet-crossbred (R_x) ewes but only 0.8 to 1.3% more than for lambs from

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Table 1.—Sex and slaughter weight effects on separable and chemical composition of soft tissues and tenderness of cooked muscle from 5th rib cross-section of carcasses

Variable	Nos	Soft tissue: Separable (pct) Lean	Soft tissue: Separable (pct) Fat	Soft tissue: Chemical (pct) Fat	Soft tissue: Chemical (pct) Protein	Soft tissue: Chemical (pct) H_2O	Soft tissue: Chemical (pct) Ash	Longissimus: Chemical (pct) Fat	Longissimus: Chemical (pct) Protein	Longissimus: Chemical (pct) H_2O	Longissimus: Chemical (pct) Ash	W-B shear (kg)
Sex:												
Wether	400	[2]55.2	[2]44.8	[2]44.1	[2]12.2	[2]43.4	[2]0.55	[2]7.9	[2]21.9	[2]69.3	0.91	[2]3.1
Ewe	410	52.8	47.2	46.8	11.6	41.4	.51	8.8	21.7	68.5	.90	2.9
Live weight:[1]												
Heavy, 125 lbs	411	[2]52.6	[2]47.4	[2]47.0	[2]11.6	[2]41.2	.51	[2]8.9	21.7	[2]68.2	.89	3.0
Light, 114 lbs	399	54.7	45.3	44.7	12.2	43.0	.54	7.9	21.8	69.2	.91	3.0
Regression on carcass weight ... lbs	1/750	[2]–.39	[2].39	[2].34	[2]–.07	[2]–.25	[2]–.005	.006	–.012	–.019	–.000	.006

[1]125 and 110 lb minimum slaughter weights; 65 and 59 lb mean hot carcass weight.
[2]P<.01.

Table 2.—Sire breed of lamb effects on separable and chemical composition of soft tissues and tenderness of cooked muscle from 5th rib cross-section of carcasses

		Soft tissue						Longissimus				W-B
		Separable (pct)		Chemical (pct)				Chemical (pct)				shear
Variable	Nos.	Lean	Fat	Fat	Protein	H_2O	Ash	Fat	Protein	H_2O	Ash	(kg)
Breed of sire:												
Suffolk	238	[2]55.9	[2]44.1	[2]43.6	[2]12.3	[2]43.8	[1]0.55	8.5	[1]21.6	68.9	0.90	[1]2.8
Hampshire	267	53.7	46.3	45.8	11.9	42.1	.53	8.2	21.9	68.9	.91	3.0
Oxford	305	52.3	47.7	47.0	11.5	41.2	.51	8.4	21.8	68.8	.91	3.1

[1]$P < .05$.
[2]$P < .01$.

Table 3.—Maternal grandparent breed effects on separable and chemical composition of soft tissues and tenderness of cooked muscle from 5th rib cross-section of carcasses

		Soft tissue						Longissimus				W-B
		Separable (pct)		Chemical (pct)				Chemical (pct)				shear
Variable	Nos.	Lean	Fat	Fat	Protein	H_2O	Ash	Fat	Protein	H_2O	Ash	(kg)
Sire of dam:												
Finn-X	360	[2]53.2	[2]46.8	[2]46.6	[2]11.7	[2]41.6	[2]0.51	[2]8.7	21.7	[2]68.4	0.88	3.0
Ramb-X	189	54.8	45.2	44.7	12.1	43.0	.54	8.0	21.8	69.1	.91	3.0
Purebred	261	54.0	46.0	45.3	12.0	42.4	.53	8.3	21.8	69.0	.91	3.0
Dam of dam:												
Suffolk	103	[2]54.5	[2]45.5	[2]44.9	[2]12.2	[2]42.9	[1].52	8.0	[1]22.0	69.1	[1].91	3.1
Hampshire	92	53.5	46.5	45.9	11.8	42.2	.53	8.3	21.6	69.0	.91	3.0
Rambouillet	103	56.0	44.0	43.8	12.3	43.8	.54	8.2	21.7	69.1	.90	2.8
Dorset	132	53.1	46.9	46.0	11.8	41.7	.53	8.3	21.8	68.8	.93	3.3
Targhee	140	54.0	46.0	45.2	12.1	42.4	.54	8.5	21.8	68.6	.91	3.0
Corriedale	106	52.8	47.2	46.7	11.6	41.5	.53	8.4	21.8	68.9	.90	2.9
Coarse Wool	134	53.9	46.1	45.8	11.9	42.2	.50	8.5	21.8	68.6	.86	2.9

[1]$P < .05$.
[2]$P < .01$.

purebred (P) ewes (Table 3). Again, the higher fat content of muscle in lambs from F_x than from R_x dams was small (.7%) but still proportionately larger than that in all soft tissue (i.e., .7/8.0 = .09 *vs* 1.6/45.2 = .04). Tenderness of cooked muscle was identical for lambs from F_x, R_x, and P ewes.

Breed of lambs maternal granddam also had real effects on separable and chemical fat content of soft tissues, ranging from 44 to 47%. Lambs from ½ Rambouillet ewes were least fat, followed by those from ½ Suffolk and ½ Targhee ewes; those from ½ Corriedale were fattest, slightly higher than those from ½ Dorset or ½ Hampshire ewes. However, no real differences in fat content or tenderness of muscle were detected.

Literature Cited

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PRODUCTION SYSTEMS

THE EFFECT OF LEVEL OF MANAGEMENT INTENSIVENESS UPON EWE PRODUCTIVITY

Thomas G. Jenkins[1] and Mike H. Wallace

Summary

For Phase 1, increasing the number of exposures per ewe maintained, plus other components of increased intensiveness of management, had a positive effect on number of lambs weaned per ewe maintained in the flock. Using number of lambs weaned per ewe maintained as the criterion of efficiency, the high system was 56% more efficient than the low and 13% more efficient than the medium. Reproductive performance data (lambs weaned per ewe exposed) on a yearly basis for Phase 1 and Phase 2 suggest conception rate may be higher using multiple sire mating (medium and low), number of lambs born/ewe lambing tends to be highly variable across years and survival rate of lambs tends to be highest in the high and medium systems. The results presented here do not include all factors that should be considered in evaluating production systems. Ranking on an economic return may not be the same as the ranking based on the criterion used in this report.

Introduction

Evaluation of efficiency of the ewe/lamb segment of a horizontally integrated market lamb industry requires consideration of the efficiencies of reproduction and preweaning development for feeder lambs. These two factors, reproduction and preweaning development, are commonly measured as productivity of the breeding females maintained in the flock. The producer has options available to him to increase ewe productivity for his enterprise by selecting strategies to increase number of lambs weaned per ewe exposed per year. However, this increase in ewe productivity requires increased levels of resource input; therefore, the increase in ewe productivity must be sufficient to offset the additional resource input.

Managerial options available to the feeder lamb producer to increase lamb production include accelerated lambing programs, use of prolific sheep breeds, increased labor at lambing to minimize lambing losses, and capital investment in facilities designed specifically for lamb production (e.g., nursery, lambing facilities, etc). The present study was designed to evaluate differences in ewe productivity (number of lambs weaned per ewe maintained per year) among production systems varying in management intensiveness.

Procedure

Three management systems varying in level of intensiveness for feeder lamb production were defined in 1975. The study consists of two phases with management regimes relatively static and the germ plasm resources utilized differing between Phase 1 (1975-77) and Phase 2 (1978-81). Particulars about and differences among the management systems are detailed in Table 1. The systems were designated high (H), medium (M), and low (L) to represent the relative magnitude of management intensiveness.

Management practices, other than those specified in Table 1, were common across the three systems. Dry, open, and pregnant ewes were maintained on simi-

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Table 1.—Management criteria for high, medium, and low sheep production systems

Item	High	Medium	Low
Lambing program	Ewes exposed to lamb three times in 2 years. Exogenous hormones used prior to spring breeding. Rams used in spring breeding photo-treated in Phase 2.[1]	Annual.	Annual.
Breeding	Multisire group mating in Phase 1 and individual sire matings in Phase 2.	Multisire group matings.	Multisire group matings.
Lambing facilities	Raised slatted floor lambing barn with jug pens after April 1979 (approximately 9 sq ft and 15 sq ft of slatted floor space/ewe in Phase 1 and 2, respectively). Conventional dry lot facilities prior to this date.	Open front poleshed with jug pens (approximately 18 sq ft and 16 sq ft/ewe in Phase 1 and Phase 2, respectively).	Open front poleshed and pasture, no jugs (approximately 12 sq ft barn and 0.9 acres and 6 sq ft barn and 1.2 acres/ewe in Phase 1 and 2, respectively).
Preweaning	Ewes and lambs fed *ad lib* in dry lot (approximately 8 sq ft in Phase 1). Phase 2 lactation period done in slatted floor facilities (approximately 15 sq ft/ewe).	Ewes and lambs in dry lot until about 30 days postpartum then maintained on pasture (approximately 0.6 acres/ewe).	Lambs and ewes maintained on pasture (approximately 0.9 acres/ewe).
Weaning	Lambs weaned at approximately 6 weeks of age.	Lambs weaned at 10 weeks of age or later.	Lambs weaned at 10 weeks of age or later.
Artificial rearing	Intensive use. Weak lambs or lambs with litter size greater than twins transferred to nursery.	Weak lambs or lambs from litter size greater than twins transferred to nursery.	Not available.
Labor	High commitment, all phases.	High commitment during lambing.	Low commitment, all phases.

[1]Rams were subjected to photo period treatment for the high system beginning in Spring 1979.

lar pastures receiving energy, protein, and mineral supplementation as deemed necessary. During breeding season, ewes were exposed to rams for approximately 5 weeks.

Lambs introduced into the artificial rearing facility from the H or M systems were housed in 6" x 24" individual pens for the first 3 days and received milk replacer via Nursette bottle. During Phase 1, the lambs remained in individual pens until approximately 8-9 days of age, at which time the lambs were placed in mixing pens. Nursery lambs were weaned from the milk replacer onto dry feed at approximately 21 days. Lambs were removed from the nursery at approximately 6 weeks of age.

Phase 1

During Phase 1 of the study, the ewe flock population across the three systems was increased with 2,200 Finn cross ewes being involved in the study by 1977. Of the 2,200 ewes involved, approximately 1,100 were assigned to the H system, and 500 ewes were assigned to each of the M and L systems. To facilitate an accelerated 8-month lambing schedule, the 1,100 ewes assigned to the H system were subsequently divided into two 550 ewe flocks.

Under the H management system, one of the two flocks was exposed every 4 months. Typical breeding seasons were August-September, December-January, and April-May. During these breeding seasons, the ewes were multi-sire mated at a ratio of approximately 30 ewes per ram. Ewes exposed during the April-May breeding season were treated with progesterone treated vaginal pessaries about 14 days prior to entering the breeding pens and removed prior to the injection of 500 IU of PMS, before the introduction of the rams. For the first 2 years of Phase 1, these ewes were lambed out in a modified open front building. Ewes lambing in 1977 were housed in a raised, slotted-floor lambing facility. Assistance was provided for any ewes experiencing lambing difficulty. Immediately after parturition, the ewe and her lamb(s) were moved to small individual pens (lambing jugs). The animals remained in the jugs for 12-36 hr, depending on the lambing rate. Those lambs that were weak, lamb(s) in excess of what could be raised by the ewe and orphaned lambs, were moved to an artificial rearing facility. Lambs raised by their dams were weaned at approximately 6 weeks of age.

Approximately 500 ewes were assigned to the medium system by 1977. These ewes were multi-sire mated during October-November and lambed out in a modified open front poleshed. Lambs were moved along with their dams to a jugging pen for 12 to 36 hr. Ewes experiencing lambing problems were provided assistance. Orphaned lambs and lambs in excess of what the ewe could raise were transported to the artificial rearing facility. When the youngest lambs attained an age of about 4 weeks, the flock was moved onto pasture until the lambs were weaned at approximately 100 days of age.

Low management ewes were multi-sire mated in October-November to lamb in March and April. These ewes were provided access to a poleshed for lambing in the pasture in which the flock was maintained. No assistance was provided at lambing time nor were lambing jugs used. Ewes were expected to raise all lambs; the nursery facility was not used for this flock. Lambs from the low management system were weaned at approximately 100 days of age.

Phase 1 Summary

Ewe performance for the three levels of management intensiveness by year are presented in Table 2. The information presented represents the total number of ewes exposed within a system for a year, the percentage of ewes lambing, lambs born/ewe lambing, lamb survival rate, and number of lambs weaned per ewe within the system. These data are averages unadjusted for other sources of variation, and the results should not be considered conclusive; however, trends may be noted that could provide insight as to the effect of management input on the systems output.

As indicated in the procedures section, during Phase 1, the population size for each system was increased across years. This increase in population size is reflected by the increasing number of exposure per year from 1975 through 1977 for all systems. The number of exposures for the high management system was two to three times greater than either the medium or low within any year. This result can be attributed to more ewes being assigned to the systems and increased opportunity for exposure due to the accelerated eight month lambing program.

Actual number of ewes lambing was available only from the high and medium systems because of management protocol imposed in the low management system. In each of the 3 years, conception rate of the medium was the largest. The advantage exhibited by the medium relative to the high (25%, 10%, and 14% for 1975, 1976, and 1977, respectively) could be partially attributed to lower conception rates of the high ewes exposed during the April-May breeding season. These results suggest, over a 3-year period, that an accelerated lambing program would not be expected to substantially decrease conception relative to a flock maintained on a typical annual lambing system.

Lambs born is expressed on a per ewe lambing basis for high and medium and on a per ewe exposed basis for the low system. The results are variable over the 3 years contributing to Phase 1 with rank changes between high and medium. Both of these systems approach an average over the 3 years of two lambs born per ewe lambing. Lambs weaned per lambs born was lowest for the low system possibly attributable to late winter-early spring

Table 2.—Phase 1 summary of ewe productivity by year for ewes assigned to 3 (high, medium, and low) management systems varying in intensiveness of management[1, 2, 3]

Management system		Breeding year 1975 High	1975 Medium	1975 Low	1976 High	1976 Medium	1976 Low	1977 High	1977 Medium	1977 Low
Number of ewes		428	218	225	749	368	335	1,122	501	522
Number of exposures		690	218	225	1,472	368	335	1,447	501	522
Ewes lambing/ewes exposed	percent	53	85	NA	78	88	NA	67	81	NA
Lambs born/ewes lambing	percent	222	182	139	188	212	187	185	191	158
Lambs weaned/lambs born		73	68	61	67	77	58	66	76	51
Lambs weaned/ewes exposed	percent	85	104	85	99	143	109	82	118	81

[1]See table 1 for explanation of management systems.
[2]Ewe lambs entering the high system for only the December breeding of 1975, 1976, 1977 were 201, 177, and 445, respectively.
[3]Tabular values are based on the year ewes were exposed (i.e., lambs conceived in 1975 although born in 1976 are enumerated at 1975 data).
[4]Due to management protocol, low management figures are expressed on a per-ewe exposed basis.

time of lambing (March-April). This system had the lowest input of labor and facilities during the lambing and preweaning periods so these results are not totally unexpected. With the exception of 1975, the medium system exhibited the greatest lamb survival rate.

Lambs weaned per ewe exposed is a function of number of ewes exposed, ewes lambing, drop rate, and survival rate of the lambs. Based on this criteria, the medium system exhibited an advantage for the 3 years. Relative to the high system for these years, the medium system had the fewest exposures, the highest survival rate (except 1975), and highest drop rate. With advantages in these components, the medium weaned .2, .44, and .36 more lambs than did the high system per ewe exposed. The percentage of lambs weaned per ewe exposed was lowest for the low management system in 1977, equal to the high system in 1975, and excelled the high system in 1976.

The largest proportion of energetic cost for a ewe/lamb production system is expended on maintaining the breeding flock. This maintenance energy cost includes that required during all stages of production. Ewe maintenance costs compose approximately 75% of the total annual feed requirement. By increasing the number of lambs produced annually, the energetic efficiency (biological) per ewe can be improved. To provide a measure of the effect of management options for this measure of efficiency, the ewe performance data have been expressed on a per ewe maintained per year basis (Table 3).

Based on this criteria, the high management system exhibited the greatest cumulative productivity for the 3 years in Phase 1. The high management system weaned approximately .2 and .5 more lambs per ewe maintained than did the medium and low systems, respectively. This favorable result is directly attributable to the management option of an accelerated lambing program. With approximately twice as many ewes maintained per year, the high management system had approximately 60% more exposures, 30% more lambings per ewe maintained, and 25% more lambs born than the medium system. Survival rates in the high and medium system were in favor of the medium, with the low management system survival rate substantially lower.

Table 3.—Phase I comparison of ewe productivity per average number of ewes maintained in a flock per year for 3 systems (high, medium, low) of lamb production varying in intensiveness of management[1]

Item		Management system	
	High	Medium	Low
Average number of ewes maintained	766.0	362.3	360.6
Exposures/ewe maintained/yr ... percent	157.1	100.0	100.0
Lambings/ewe maintained/yr ... percent	108.1	84.1	NA[2]
Lambs born/ewe maintained/yr ... percent	207.3	165.4	164.0
Lambs weaned/lambs born ... percent	67.6	74.8	54.9
Lambs weaned/ewe maintained/yr ... percent	140.2	123.8	90.0

[1]See table 1 for explanation of management systems.
[2]This information is not available because of management protocol

Upon comparing the medium and low systems, the performance per ewe maintained was very similar with the exception of lamb survival rate. The medium system weaned .2 more lambs per ewe maintained than the low system.

If the efficiency of ewe productivity is measured only in terms of lambs weaned per ewe maintained, the above results indicate a favorable relationship between increased level of management intensiveness and efficiency. The largest advantage for the high system may be attributed to increased opportunity for the ewes to be exposed, thus produce lambs. It must be cautioned, however, that the ranking on an economic basis may not be the same as the one reported in this paper. With increased level of management intensiveness, there is an associated increase in financial input.

Phase 2 Progress Report

Beginning with the August-September breeding in 1978, the study was modified in terms of numbers of ewes involved and germ plasm. The management criteria described in Table 1 was modified for Phase 2. Approximately 1,100 1/2 or 1/4 (550 of each) Finn yearling or ewe lambs were assigned to the study with about 550, 275, and 275 of these designated for high, medium, and low systems, respectively. These ewes are continuing to be exposed and ewe productivity data are being collected. The ewes in each system are mated to Suffolk or Columbia rams.

Ewe productivity data have been collected from two breeding seasons for the medium and low management systems and for five breeding seasons for the high management systems. Phase 2 data will be continued to be collected through the fall 1981 lambing seasons. Lambs produced during 1981 will be sampled from each of the production systems and fed *ad libitum* until they reach 115 lb. Feed intake data will be collected during the feeding period. Upon reaching market weight, the lambs will be slaughtered with carcass weight and quality grades collected.

Phase 2 breeding was initiated with the exposure of high management system ewe lambs in September 1978. Approximately 16% of the females exposed were ewe lambs with an average age of 150 days. At this age, viable reproduction status would not have been attained by the majority of these ewe lambs and the conception rate would be expected to be low. The percentage of ewes lambing for the high system during 1978 was lower than the medium (60% *vs* 82%, respectively). The percentage of ewes lambing in the medium system exceeded the high (82.5 *vs* 72.5, respectively) again in 1979.

Lambing rank for ewe productivity based on number of lambs weaned per ewe exposed was medium, low, and high. The conception rate, as reported previously, was highest for the medium system, and this system also had the highest survival rate. Although the conception rate for the low system was not determined, it would be expected to be similar to the medium system. The low management system survival rate also exceeded that of the high system through the first year of Phase 2.

PRODUCTION SYSTEMS

ECONOMICS OF FEEDING LAMBS TO HEAVIER WEIGHTS

Virden L. Harrison[1] and John D. Crouse

Introduction

Several factors indicate that the U.S. sheep industry may be in serious trouble. Lamb has disappeared from many grocery stores and, where it does appear, it is generally priced higher than comparable beef and pork cuts. Many slaughter plants have discontinued slaughtering lambs due to lack of sufficient numbers to make the operation profitable. Consequently, lamb producers are forced to find marketing outlets at more distant points, thus increasing the costs of marketing sheep. Feeding of lambs by packers has increased during the period of decreasing supply to insure themselves a more steady supply of lambs for slaughter. This, too, tends to reduce the producer's bargaining position.

Production of heavy market lambs could substantially increase quantity and efficiency of lamb production and reduce the processing costs per pound of lamb meat. The product of a heavy market lamb, if it is to be desired by the consumer, must have acceptable palatability devoid of offensive flavor and aroma. Lambs tend to develop objectionable odor and flavor as their weights increase. Therefore, in developing a heavy market lamb technology, the enterprise must be managed for highly desirable, efficiently produced carcasses.

Design of Experiment

This analysis is based on a MARC experiment conducted to determine the characteristics of lambs fed to heavier than normal slaughter weights. A 2 x 3 factorial arrangement involving 441 ram and ewe lambs in three ration energy density treatments (Table 1) with two replications was conducted in 1976 and early 1977. Lambs were weighed and their feed consumption was determined at 28-day intervals (Table 2). Lambs within each pen were serially slaughtered and carcass measurements were taken. The heaviest group averaged about 154 lb liveweight at slaughter.

Regression equations were derived for rams and ewes under each diet relating the following items to days on feed: growth, feed consumption, dressing percentage, quality grade, and yield grade. These relations, as well as alternative lamb pricing schemes and feed cost

[1]Virden L. Harrison is an agricultural economist, ERS, USDA, stationed at MARC.

Table 1.—Composition of rations for heavy lamb production

Item	Energy level: Low	Medium	High
		Percent	
Ingredient:			
Alfalfa, dehydrated	89.32	51.60	14.30
Corn grain	8.41	33.40	59.40
Soybean meal	0	8.80	18.20
Limestone	0	.52	2.60
Sodium tripolyphosphate	1.00	.76	.55
Ammonium chloride	1.25	1.20	1.20
Chelated trace minerals	.01	.01	.01
Durabond	0	3.75	3.75
Dry matter	93.70	92.67	89.86
Composition (dry matter basis):			
Crude protein	19.41	18.29	21.03
		Megacalories per pound	
Digestible energy[1]	1.253±0.016	1.350±0.015	1.539±0.010
Metabolizable energy[1]	1.011± .016	1.106± .014	1.298± .010

[1]Based on digestion trial of 5 ram lambs per ration.

Table 2.—Raw data on growth, feed consumption, and efficiency of rams and ewes on three ration energy levels for various feeding periods[1]

Item	Rams: Low energy[2]	Rams: Medium energy	Rams: High energy	Ewes: Low energy	Ewes: Medium energy	Ewes: High energy
			Number			
Lambs	72	69	71	76	77	76
			Pounds			
Beginning weight[3]	49.4	48.9	48.9	47.8	47.2	48.1
Liveweight at day:						
30	71.0	75.6	77.8	65.3	67.9	69.4
58	85.1	88.2	93.3	75.4	78.9	80.5
86	99.6	100.5	108.2	86.9	88.2	90.4
114	117.7	121.3	126.5	101.2	103.2	102.5
142	129.0	130.7	132.1	112.7	113.8	113.3
170	135.4	136.7	137.6	119.0	116.8	117.5
212	147.0	155.4	153.7	134.7	132.9	135.1
Feed consumption to day:			Mcal ME			
30	104	116	118	104	107	105
58	234	240	242	220	221	217
86	369	366	366	335	330	321
114	534	514	514	477	451	436
142	695	649	637	617	575	552
170	855	790	766	767	699	673
212	1,096	1,009	992	971	885	872
Feed/gain to day:			Mcal ME/lb gain			
30	4.76	4.35	4.08	5.94	5.17	4.94
58	6.53	6.12	5.44	7.98	6.99	6.71
86	7.35	7.08	6.17	8.57	8.03	7.58
114	7.80	7.12	6.62	8.94	8.07	8.03
142	8.71	7.94	7.67	9.53	8.62	8.48
170	9.93	8.98	8.66	10.75	10.02	9.71
212	11.20	9.48	9.48	11.20	10.34	10.02

[1]Data are expressed as treatment means at successive weigh periods.
[2]Ration energy levels are described in Table 1.
[3]Weight at beginning of feeding period.

levels (Table 3), were used to determine the profitability of feeding lambs to heavier weights.

Results and Conclusions

Rams fed a high-energy diet under simulated price and cost conditions generated profits at weights of 154 lb and above (Table 4). But with this diet, highest net returns were obtained at 143, 121, and 110 lb liveweight for low, medium, and high feed price levels, respectively. These weights are above the 90- to 110-lb slaughter weight range typical in the industry.

Optimal ewe lamb slaughter weights were generally about 11 lb lower than ram weights, and profits per ewe lamb were lower (Table 5). While profits for ewes fed the high-energy diet were obtained at weights up to 143 lb, assuming low feed prices, net returns were maximized at 121, 99, and 99 lb for the low, medium, and high feed price levels, respectively.

The high-energy density diets result in improved feed efficiency (energy required per unit of gain) for ram lambs, compared to the low-energy diet (fig. 1). Ewe lambs, however, exhibited little change in feed efficiency as one diet was

Table 3.—Feed price assumptions for low-, medium-, and high-energy rations, assuming three price levels

Item	Feed price level: Low	Baseline	High
	Dollars per cwt		
Principal feeding ingredient price:			
Alfalfa, dehydrated	3.80	4.50	5.20
Corn, grain	3.33	4.20	5.00
Soybean meal	6.00	8.00	10.00
	Dollars per Mcal ME[1]		
Ration energy level:			
Low	0.04173	0.04926	0.05675
Medium	.04019	.04845	.05646
High	.03352	.04412	.05235

[1] Mcal ME = megacalories of metabolizable energy

Table 4.—Net returns per ram lamb for various feed cost levels and lamb valuation schemes by ration energy level and liveweight[1]

Live-weight	Days on feed	Low feed cost B	Low feed cost C	Low feed cost D	Baseline feed cost B	Baseline feed cost C	Baseline feed cost D	High feed cost B	High feed cost C	High feed cost D
		Lamb valuation scheme[2]								
Pounds	*Days*	*Dollars per ram*								
		LOW-ENERGY RATION								
66	27	−6.92	−8.79	−8.79	−7.62	−9.49	−9.49	−8.31	−10.18	−10.18
77	40	−4.04	−5.85	−5.85	−5.17	−6.98	−6.98	−6.29	−8.10	−8.10
88	57	−1.83	−3.46	−3.46	−3.54	−5.17	−5.17	**−5.24**	−6.87	−6.87
99	77	−.43	−1.82	−1.82	**−2.89**	**−4.28**	**−4.28**	−5.34	**−6.73**	**−6.73**
110	101	**−.30**	**−1.08**	**−1.12**	−3.72	−4.50	−4.55	−7.13	−7.91	−7.95
121	129	−.68	−1.38	−3.64	−5.28	−5.98	−8.24	−9.86	−10.56	−12.82
132	162	−2.65	−2.92	−7.38	−8.69	−8.96	−13.42	−14.69	−14.96	−19.42
143	198	−6.14	−5.91	−12.57	−13.88	−13.65	−20.31	−21.58	−21.35	−28.01
154	240	−11.25	−10.45	−19.31	−21.00	−20.20	−29.06	−30.71	−29.91	−38.77
		MEDIUM-ENERGY RATION								
66	24	−3.92	−5.81	−5.81	−4.67	−6.56	−6.56	−5.39	−7.28	−7.28
77	36	−.51	−2.25	−2.25	−1.69	−3.43	−3.43	−2.83	−4.57	−4.57
88	52	2.35	.85	.85	.59	.89	.89	−1.10	−2.58	−2.58
99	71	4.59	3.44	3.44	2.12	.97	.97	**−.26**	−1.41	−1.41
110	93	5.98	5.27	**5.23**	**2.62**	1.91	**1.87**	−.63	**−1.34**	**−1.38**
121	120	**6.62**	6.44	4.18	2.18	**2.00**	−.26	−2.13	−2.31	−4.57
132	151	6.17	**6.60**	2.14	.42	.85	−3.61	−5.15	−4.72	−9.18
143	187	4.63	5.75	−.91	−2.64	−1.52	−8.18	−9.68	−8.56	−15.22
154	228	1.86	3.76	−5.10	−7.18	−5.28	−14.14	−15.95	−14.05	−22.91
		HIGH-ENERGY RATION								
66	20	−.37	−2.37	−2.37	−1.12	−3.17	−3.17	−1.75	−3.80	−3.80
77	31	3.76	1.94	1.94	2.46	.64	.64	1.46	−.36	−.36
88	45	7.37	5.86	5.86	5.41	3.90	3.90	3.89	4.28	4.28
99	63	10.43	9.33	9.33	7.61	6.51	6.51	5.43	4.33	4.33
110	86	12.78	12.22	**12.18**	8.88	8.32	**8.28**	**5.85**	**5.29**	**5.25**
121	112	14.35	14.43	**12.17**	**9.11**	**9.19**	6.93	5.05	5.13	2.87
132	144	**14.98**	15.79	11.33	8.13	8.94	4.48	2.81	3.62	−.84
143	180	14.52	**16.18**	9.52	5.75	7.41	.75	−1.05	.61	−6.05
154	223	12.93	15.52	6.66	1.90	4.49	−4.37	−6.66	−4.07	−12.93

[1] Net returns per lamb at each weight level equal lamb value minus lamb feeder cost ($23.00 per lamb) minus feed cost, minus $2.50 per lamb, which represents veterinary, sales expenses, repairs, fuel, and miscellaneous minus $0.0433 times days on feed, which represents labor, investment, and interest charges.

[2] Lamb value schemes are as follows:

(B) $50/cwt adjusted by $1 for each dressing percentage below or above 51.

(C) $50/cwt adjusted as B and adjusted by $.80 for each quality grade unit below or above 11.5.

(D) $50/cwt adjusted as C and a reduction in value of $20/cwt for weight in excess of 110 pounds.

Note: Numbers set in boldface indicate the point at which highest net return (or lowest net loss) is achieved.

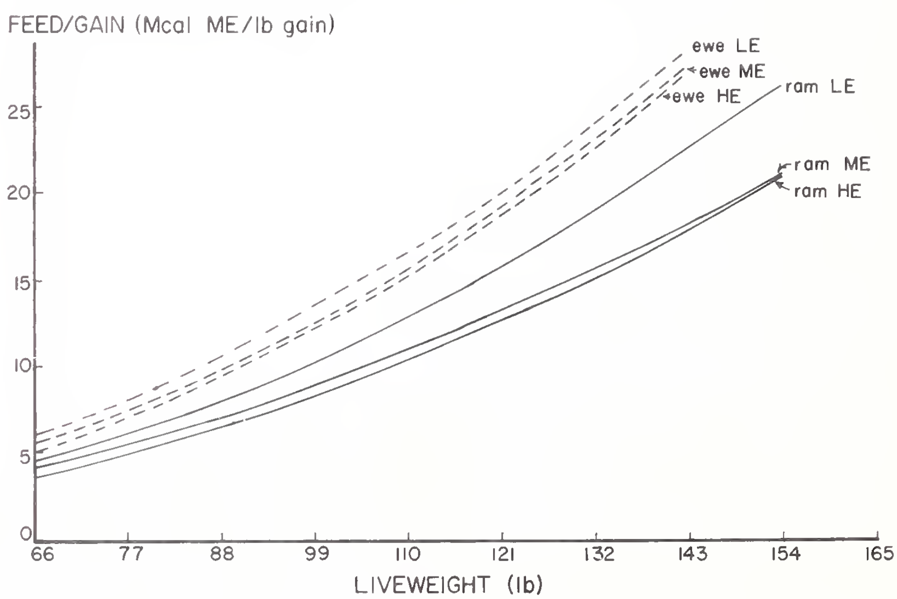

Figure 1—Effect of liveweight on instantaneous feed efficiency for rams and ewes by ration energy level.

Table 5.—Net returns per ewe lamb for various feed cost levels and lamb valuation schemes by ration energy level and liveweight[1]

Live-weight	Days on feed	Low feed cost B	Low feed cost C	Low feed cost D	Baseline feed cost B	Baseline feed cost C	Baseline feed cost D	High feed cost B	High feed cost C	High feed cost D
		Lamb valuation scheme[2]								
Pounds	*Days*	*Dollars per ewe*								
		LOW-ENERGY LEVEL								
66	36	–6.14	–7.37	–7.37	–7.11	–8.34	–8.34	–8.06	–9.29	–9.29
77	54	–3.94	–4.97	–4.97	–5.47	–6.50	–6.50	**–6.99**	**–8.02**	**–8.02**
88	77	–2.74	–3.47	–3.47	**–5.04**	**–5.77**	**–5.77**	–7.33	–8.06	–8.06
99	105	**–2.68**	–3.04	–3.04	–5.97	–6.33	–6.33	–9.23	–9.59	–9.59
110	139	–2.90	**–2.81**	**–2.85**	–7.42	–7.33	–7.37	–11.92	–11.83	–11.87
121	179	–5.58	–4.98	–7.24	–11.62	–11.02	–13.28	–16.62	–16.02	–18.28
132	225	–11.37	–10.20	–14.66	–19.22	–18.05	–22.51	–27.03	–25.86	–30.32
143	278	–17.89	–16.08	–22.74	–27.90	–26.09	–32.75	–37.86	–36.05	–42.71
		MEDIUM-ENERGY LEVEL								
66	32	–3.05	–4.39	–4.39	–3.99	–5.33	–5.33	–4.91	–6.25	–6.25
77	50	–.31	–1.34	–1.34	–1.83	–2.86	–2.86	–3.30	–4.33	–4.33
88	73	1.44	.85	.85	–.86	–1.45	–1.45	**–3.09**	–3.68	–3.68
99	102	**2.99**	**2.94**	**2.94**	**–.32**	**–.37**	**–.37**	–3.54	**–3.59**	**–3.59**
110	138	1.20	1.81	1.77	–3.40	–2.79	–2.83	–7.85	–7.24	–7.28
121	182	–1.11	.27	–1.99	–7.29	–5.91	–8.17	–13.28	–11.90	–14.16
132	233	–5.25	–3.02	–7.48	–13.35	–11.12	–15.58	–21.20	–18.97	–23.43
143	294	–11.39	–8.19	–14.85	–21.77	–18.57	–25.23	–31.84	–28.64	–35.30
		HIGH-ENERGY LEVEL								
66	30	–.23	–1.58	–1.58	–1.34	–2.69	–2.69	–2.19	–3.54	–3.54
77	47	3.32	2.28	2.28	1.52	.48	.48	.13	–.91	–.91
88	70	6.07	5.48	5.48	3.32	2.73	2.73	**1.18**	.59	.59
99	99	7.83	7.79	7.79	**3.83**	**3.79**	**3.79**	.73	**.69**	**.69**
110	135	**8.42**	9.09	**9.05**	2.83	3.50	3.46	–1.51	–.84	–.88
121	179	7.71	**9.12**	6.86	–.85	.56	–1.70	–5.72	–4.31	–6.57
132	231	5.36	7.64	3.18	–4.62	–2.34	–6.80	–12.36	–10.08	–14.54
143	293	1.29	4.55	–2.11	–11.57	–8.31	–14.97	–21.55	–18.29	–24.95

[1]Net returns per lamb at each weight level equal lamb value minus lamb feeder cost ($23.00 per lamb) minus feed cost, minus $2.50 per lamb, which represents veterinary, sales expenses, repairs, fuel, and miscellaneous minus $0.0433 times days on feed, which represents labor, investment, and interest charges.
[2]Lamb value schemes are described in footnote 2 of Table 4.
Note: Numbers set in boldface indicate the point at which highest net return (or lowest net loss) is achieved.

compared to another. Energy consumed was shown to be an increasing function of weight for both sexes, with the result that about a fivefold increase in feed energy was required to put on a pound of gain at 143 versus 66 lb liveweight. Value per lamb increases at a decreasing rate as weight increases and is overtaken by the increasing costs, resulting in first increasing net returns per lamb, then decreasing net returns as lamb weight increases (fig. 2).

Feed efficiency was higher for ram than ewe lambs at each feed ration and weight level. Dressing percentages and quality grades were lower for rams, but their effect on lamb value was not enough to offset the ram's superior feed efficiency. Therefore, rams were generally more profitable than ewes for all rations tried and at all slaughter weights.

For both sexes, the high-energy density diet was superior to other diets in net returns per lamb because: (1) costs per unit of metabolizable energy were lower, (2) feed efficiency was improved (especially for rams), (3) growth rate was increased, thus reducing time in the feedlot, and (4) lamb value at any weight was increased as a result of higher dressing percentages and quality grades. Under medium feed price levels and assuming no discount for above normal slaughter weights, net returns per ram on the high-energy diet were $9.19 at their optimal weight of 121 lb, which required 112 days in the feedlot. Under these conditions, net returns per ewe were $3.79 at their optimal weight of 99 lb, which required 99 days in the feedlot.

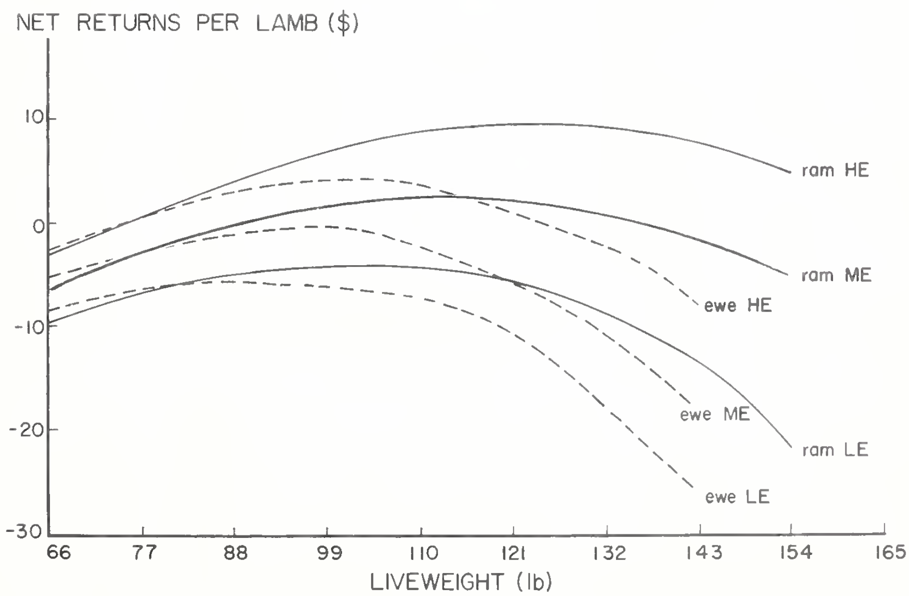

Figure 2—Net returns per lamb as liveweight changes, rams and ewes by energy ration, assuming baseline costs.

ANIMAL HEALTH

DISEASE SURVEILLANCE IN A SHEEP RESEARCH FLOCK UNDER INTENSIVE MANAGEMENT

William G. Kvasnicka[1], Virden L. Harrison, and Mike H. Wallace

Summary

A continuous disease monitoring system to obtain information on the occurrence and extent of diseases within the MARC sheep flocks was established early in 1980. Data from the spring 1980 lambing season are presented. However, no analysis or detailed summaries of health problems can be made as yet.

Introduction

Sheep diseases are thought to be a major source of loss to the sheep industry. Numerous publications report mortality rates in range flocks. Such rates have been reported as high as 36.4% (Moule, 1954) and as low as 10% (Matthews and Ogden, 1957). Safford and Hoversland reported that 23½% of the lambs in the Montana Agricultural Experiment Station range flocks died between birth and weaning in the years of 1952, 1953, and 1954 (Safford, 1960). The USDA reported losses in 15 western states for 1974 to be 23.2% for lambs and 10.4% for adult sheep. Half of the lamb losses and two-thirds of adult sheep losses were due to diseases, parasites, and weather stress; the remainder to predation (Gee, 1977).

These published reports enumerate the losses from diseases occurring under traditional range or farm flock management. The MARC sheep research program places highest priority on the development of intensive sheep production technology that can be implemented by commercial sheep producers within a short time frame. Evaluation of the technology developed must include the influence that the various management procedures established has on disease incidence. To make such an evaluation, a disease surveillance system is required.

Surveillance means an active intelligence and accounting process intended to continuously monitor the overall disease and health status of a population or group of populations. The surveillance process has several necessary components: (1) the collection of data; (2) the collation and analysis of data; and (3) the expression, interpretation, and prompt dissemination of disease intelligence (Schwabe *et al.*, 1977). A continuous disease surveillance system will form a data base to scrutinize the patterns of animal diseases. Disease is studied en mass rather than in the individual animal. The agent causing a disease is of concern but of equal importance is to enumerate the factors influencing that cause. The epidemiological information generated by a continuous disease surveillance system will provide the knowledge required to successfully prevent and control specific disease problems. The statistical information will be of value to the sheep industry as producers attempt to evaluate the changes required to intensify production. The economic facet of disease will be of importance to research scientists and the industry. What does preventive medicine cost? Does disease have any influence on feed efficiency? What does it cost to treat the various disease conditions? What is the financial impact of each mortality? Finally, computer based optimization models could be developed to assist in wisely choosing from among the flock health program alternatives offered.

Objectives

The objective is to establish a continuous disease monitoring system to obtain information on the occurrence and extent of diseases within the MARC sheep flock.

(1) Determine the level of morbidity and mortality experienced,
(2) Detect the emergence of new diseases,
(3) Determine the husbandry characteristics and the environment in which disease is found,
(4) Gather data for assessing the economic impact of disease,
(5) Evaluate the efficacy of individual and flock treatments, preventive medicine measures and health programs.

Methods

Achievement of the experimental objectives requires careful examination of three specific factors. First is collection and careful evaluation of all aspects of the "history" involved. Second is enumeration of those environmental factors that may influence disease incidence. Third is the necropsy examination of the patient.

Information collected for all sheep deaths and sick individuals and flocks includes:

(1) Patient data such as breed, sex, age, I.D. number, and estimated body weight,
(2) Disease history: previous sickness, changes noted in physiological functions, prior treatment, and prior disease control measures,
(3) Management history: recent nutrition, breeding history, climate, and all other general management factors involved.

All sheep that die are subjected to a postmortem examination. Routine daily flock inspections are made to determine the health status of individuals as well as the flock. Sicknesses that are not considered "routine" are handled by the staff veterinarian, who diagnoses the problem and prescribes the treatment. The above data on sick or dead animals is recorded on two forms, and the information is then computerized and made available for analysis and control. Quarterly morbidity and mortality summaries are provided from this computerized data. These data will then be used to determine the economic impact of health problems and make possible measures for disease avoidance.

Results and Discussion

This disease surveillance project began in early 1980, and data on health problems and causes of death are being continuously collected. However, no analysis or detailed summaries of health problems have been made as yet. The 1980 spring lambing results are presented as preliminary information.

Table 1 presents the 1980, January through June, lambing results and preweaning mortality rates. Four different general types of management were utilized. In slotted floor confinement, ewes were confined to slotted floors 2 to 4 weeks pre-lambing until weaning (at about 38 days). In dry lot confinement, ewes were confined in dry lot facilities with conventional barn access from the last trimester of pregnancy through to weaning (at 44 days to 56 days). The shed lambed flocks reared on pasture were lambed in conventional dry lot barns and were moved to pasture when the lambs were about 30 days of age until weaning (at 56 to 70 days). The pasture lambed flocks were lambed on pasture during May with access to conventional dry lot

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Table 1.—Pre-weaning lamb mortality rates by facility management, January-June 1980

Type of management[1]		Lamb drop[2]	Barn mortality[3]	Artificially reared lambs[4]	Artificially reared lambs mortality[5]
Slotted floor confinement	Percent	195.1	20.1	12.8	39.4
	Number	3,443	693	442	174
Drylot confinement	Percent	168.2	28.3	6.6	46.0
	Number	1,130	320	74	34
Shed lambed reared on pasture	Percent	177.2	25.1	9.4	41.6
	Number	1,198	301	113	47
Pasture lambed minimum care	Percent	[6]—	23.7	[6]—	[6]—
	Number	354	84		
Total	Percent	[7]182.8	22.8	10.3	40.5
	Number	6,125	1,397	629	255

[1]See text for explanation.
[2]Number of lambs born; percent lambs born per ewe lambing.
[3]Pre-weaning lamb mortality at facility of birth.
[4]Lambs transferred to artificial rearing facilities.
[5]Pre-weaning lamb mortality at artificial rearing facilities.
[6]Number of ewes lambing is unknown.
[7]Number of ewes actually lambing in minimum care band is unknown. For purposes of calculation, number of ewes bred was utilized for calculation of total percent lambs born per ewe lambing.

barns. However, these flocks were given minimal care at lambings, i.e., no individual attention.

These data are presented only for record information purposes, and no conclusions can be drawn concerning the suitability of the different types of facilities management. Experiments are underway that call for different facility types and levels of assistance at lambing time.

Table 2 presents the causes of pre-weaning lamb mortality.

The collection of this type of information can in the future be invaluable in the evaluation of management and health procedures. Data collection is ongoing, and summaries and analyses will be provided in the future.

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Table 2.—Causes of pre-weaning lamb mortality by facility management, January-June 1980

Type of management		Total mortality	Still births	Pneumonia	Injury	Starvation	Enteritis	Unknown	Predator	Other
Slotted floor confinement	Percent[1]	20.1	7.7	3.8	2.0	2.2	1.2	2.6	—	0.8
	Number	693	266	130	67	74	40	88	—	28
Dry lot confinement	Percent[1]	28.3	6.3	8.2	3.2	3.8	1.8	4.4	—	0.6
	Number	320	71	93	36	43	20	50	—	7
Shed lambed reared on pasture	Percent[1]	25.1	7.9	5.7	2.1	3.8	1.1	3.3	0.8	0.4
	Number	301	95	68	25	46	13	40	10	5
Pasture lambed minimum care	Percent[1]	23.7	0.9	1.4	0.9	10.2	0.6	8.5	1.1	0.3
	Number	84	3	5	3	36	2	30	4	1
Artificially reared	Percent[1]	40.5	—	12.6	1.8	12.7	5.7	3.7	—	4.1
	Number	255	—	79	11	80	36	23	—	26
Total	Percent[1]	27.0	7.1	6.1	2.3	4.6	1.8	3.8	0.2	1.1
	Number	1,652	435	375	142	279	111	231	14	67

[1]Percentages based on total lambs born or entering facility.

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